Engineering UK 2018

The state of engineering

EngineeringUK

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Foreword

The Engineering UK Report, now in its 20th year, provides a comprehensive analysis of engineering's economic contribution and the composition of its workforce, as well as the extent to which the supply through the education and training pipeline is likely to meet future needs and demand for engineering skills.

Across the years, the report's key message has remained largely the same: the engineering sector is of vital importance to the UK, yet demand for people with engineering skills is not being met by supply through the UK education pipeline. Concerted effort is needed to address the shortfall of engineers if these economic and social contributions are to be maintained.

This year's report, using an updated analysis by Warwick Institute for Employment Research of engineering jobs and industries, **identifies an annual demand for 124,000 engineers and technicians with core engineering skills across the economy.** There is an additional requirement for 79,000 "related" roles requiring a mixed application of engineering knowledge and skill alongside other skill sets. Given the current supply of talent coming through the education pipeline, **we anticipate an annual shortfall of between 37,000 and 59,000 engineering graduates and technicians** to fill these core engineering roles. Looking at the supply of graduates specifically, if all those we estimate to be eligible to take up graduate engineering roles did so, the shortfall would be at least 22,000; in reality, since many do not, the shortfall is significantly higher.

Engineering – far from being limited to the hard hat stereotype so often perceived – is a diverse field that touches every part of daily life, driving forward everything from cleaner air to faster broadband. Increasingly, the fusion between the digital, physical, and biological is both leading to new fields of engineering and adding to the already significant demand for highly skilled labour. As we move further towards an hourglass economy, fuelled by the fourth industrial revolution, there are clear implications for the engineering and technology sector and its skills needs. And as the sector and its skills needs change, so too does the context in which it operates. The UK's decision to leave the European Union and changes to education policy offer both exciting opportunities and significant challenges for the future.

In our view, the key to addressing the future demand for engineers is encouraging young people to study STEM subjects and pursue engineering-related qualifications. Our report highlights a number of case studies of good practice already taking place within industry and the education sector. And there is positive movement. For example our analysis shows that:

- the proportion of young people aged 11 to 19 who would consider a career in engineering has risen from 40% in 2013 to 51% in 2017
- the number of people achieving success in engineering-related apprenticeships in England grew by 9.3% in 2015/16 over the previous year, more than double the rate across all subject sector areas
- between 2011/12 and 2015/16, the number of engineering and technology students in higher education increased by 1.5% while overall student numbers declined by 8.8% in the same period

However, some key challenges remain.

Too few STEM teachers

Teachers have a vital role in shaping the aspirations and career trajectories of young people, but many pupils do not have access to specialist STEM teachers. In the context of a growing pupil population, the number of STEM specialist teachers has remained largely stagnant since 2015. This is starting to become an acute problem: in 2017/18 there was an estimated shortfall of 2,200 STEM trainee teachers against the DfE teacher supply model target in England. There is also an issue of retention, with teachers increasingly leaving the profession for reasons other than retirement.

Limited access to STEM careers activity

Inspirational engineering-focused engagement activities can help to ensure young people experience real life applications of engineering and are well-informed about the many doors they can open through their subject choices. Yet findings from our 2017 Engineering Brand Monitor (EBM) indicates that just 28% of young people aged 11 to 14 surveyed had taken part in a STEM careers activity in the last year. There is a need for the engineering and STEM outreach communities to work together to make such activities available to all.

Too many initiatives

The Royal Academy of Engineering estimates that more than 600 UK organisations run STEM engagement initiatives directed at schools, and there have been a host of policy efforts to address skills shortages through, for example, reform in technical education. However, coordination between activities and evidence of impact remains limited and teachers find it difficult to navigate this complex landscape. To make best use of our resources as a community and tackle the skills shortage more effectively, we must assess whether these policies and STEM engagement initiatives are having their intended effect, and better support schools to differentiate between the many opportunities on offer.

Too few women becoming engineers

While women comprise 47% of the overall UK workforce, they make up only 12% of those working in engineering occupations. The causes of this gender underrepresentation appear to be systemic and formulated at a young age. Asked how much they would like to be an engineer when they are older, just 34% of 7-11 year olds girls surveyed stated a little or very much, compared with 59% of boys of the same age. By the time girls reach age 16-19, only 25% would consider a career in engineering, less than half the proportion of boys.

Strong gender differences are apparent in educational choices. In the latest year for which data is available, only 27% of girls' A level entries were in STEM subjects, compared with 46% of boys' entries, and only 16% of first degree engineering students were women. Even after having studied engineering, there are further leakages in labour market transitions. Six months after graduating, white and/or male engineering and technology graduates are more likely to go on to work in an engineering-related role or find employment in the engineering sector than their BME and female counterparts.

Too little home grown talent

A considerable proportion of students studying engineering and technology at HE level in the UK are from EU or non-EU countries. This is most apparent at taught and research postgraduate levels, where international students make up two thirds of all engineering and technology students and as much as 80% in some engineering disciplines. Our current reliance on international students leaves the engineering pipeline extraordinarily vulnerable to changes that could occur once the UK leaves the EU.

Too little understanding of apprenticeships

Ensuring access to and take-up of high quality apprenticeships is critical for engineering yet there is concern that the introduction of the apprenticeship levy may result in a compromise in quality and lead employers to repackage existing training to drive re-skilling of their current workforce, contrary to the intention of the levy. Furthermore, there is a clear need to increase awareness and perceptions of apprenticeships as a worthy alternative to a university education. The majority (58%) of 11 to 14 year olds surveyed as part of the Engineering Brand Monitor 2017 indicated they knew almost nothing or just a little about what apprentices do and the different types of apprenticeships available– and just over a third felt an apprenticeship was a desirable pathway. Understanding was similarly low among parents surveyed, with 46% indicating little knowledge of what apprentices do.

Recommendations

There are a number of specific actions that we recommend taking to tackle the significant challenges we face in developing the talent pipeline into engineering. We do not claim they provide a comprehensive solution to the problem but we do believe that they can make a material contribution to addressing the severe shortfall in engineering skills going forward.

1. The engineering and STEM outreach communities need to make it simpler for schools to connect with employers and other providers to access high quality, engineering focused STEM engagement activity. Myriad STEM engagement initiatives exist, and there is evidence that schools often struggle to identify which are most appropriate and impactful. It is critical that the engineering and STEM outreach communities work together to inform schools of the high-quality engagement opportunities available to them and help foster stronger connections with employers. The re-positioning of the Tomorrow's Engineers programme as the go to place for such activity, designed with the needs of teachers and their pupils at its heart, will address this and we encourage the whole community to get behind this work. We also urge the government to take steps through the new Careers Strategy to encourage and support schools to engage in employer outreach activity, especially with engineering and technology companies.

Professor Dame Ann Dowling, OM DBE FREng FRS
President of the Royal Academy of Engineering

2. The engineering and STEM outreach communities should develop a better understanding of what engineering-focused careers interventions work. There is a need for better evaluation of engineering-focused inspiration activities taking place so that the engineering and STEM communities can optimise their resources. Further research and sharing of good practice is essential if we are to identify and implement the most effective methods to inspire young people to study STEM and pursue engineering careers.

3. The government should work with the engineering and education communities to increase the supply and retention of specialist STEM teachers. The shortage of STEM specialist teachers, which adversely affects the quality of STEM education young people receive, is a longstanding issue that has persisted despite many efforts to address it. It is crucial that the government, engineering industry, and education sector work together on innovative approaches to incentivise talent into the teaching profession. Further work is also needed to improve retention of specialist STEM teachers. In particular, we note the need to address the multiple-year failure to meet recruitment targets in design and technology and increase teaching capacity at A-Level physics, where the shortages are especially acute.

4. The government must ensure the UK's exit from the European Union does not exacerbate the engineering skills shortage. There is great uncertainty around the terms in which the UK will leave the EU, and the implications it will have on the country's ability to attract engineering talent from abroad. It is vital that the government actively safeguard and enhance the UK's higher education sector's status as world-class and welcoming to talent across the world. As part of this, we strongly support calls to remove international students from the net migration target. We likewise urge the government to ensure the UK higher education sector remains attractive to EU and non EU students studying STEM subjects by providing five year working visas upon graduation.

5. Engineering employers and the government should increase the supply of high quality apprenticeships. There is a need for young people to have access to quality and timely careers advice highlighting apprenticeships as a worthy alternative to a University education. The recently introduced Baker Clause is a welcome intervention by the government to promote different forms of post-16 education in schools. The engineering industry and the government must work together to better communicate the value of apprenticeships to young people and their influencers.

While we welcome the government's policies to promote apprenticeships, early data suggests this is not having the intended effect. We therefore encourage the government to review the apprenticeship levy to ensure it appropriately incentivises high quality apprenticeships at the right skills levels for young people wanting to pursue engineering.

6. The engineering community should ensure young people have a full understanding of the excitement and variety a career in engineering offers, and the potential contribution they can make as an engineer. The Year of Engineering and the momentum in government behind the Industrial Strategy present a once in a generation opportunity to change public perceptions of engineering. The "This is Engineering" campaign being delivered in partnership by the Royal Academy of Engineering and EngineeringUK aims to capitalise on that opportunity. We urge the whole engineering community to get behind both the "Year of Engineering" and "This is Engineering" campaigns to show a new generation the true potential of a career in the profession.

7. The engineering community should improve engineering's record on diversity and inclusion. Despite many efforts to address underrepresentation, diversity within the profession remains an issue and may act as an additional barrier to attracting a diverse range of young people into engineering.

It is critical that the government, engineering industry, and education community work to better understand the barriers for women, black and minority ethnic (BME) communities and people from disadvantaged backgrounds to pursue pathways into, and careers in, engineering. The Royal Academy of Engineering is currently examining the factors that influence the differences in employment outcomes among BME groups compared to white UK graduates. Employers and the higher education sector should act on the findings of the study to ensure opportunities for engineering careers are open to all.

We also encourage all stakeholders in the engineering community to adopt the Royal Academy's progression framework for diversity and inclusion and hold themselves accountable for their performance.

We hope these recommendations resonate with all those who refer to this report and that its wider findings will influence the agendas of everyone involved in the relevant aspects of government, education and employment, and so help to galvanise more action, for the good of the UK economy and for future generations.

Malcolm Brinded, CBE FREng
Chairman, EngineeringUK

Engineering UK 2018: The state of engineering
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Additional resources

Supplementary materials, including all report figures in Excel format, infographics and an annex, can be found at: **www.engineeringuk.com/research**

Engineering UK 2018: The state of engineering Synopsis

Engineering plays a vital role in the UK's economic and societal wellbeing, providing quality employment on a large scale and some of the key solutions to major global challenges. In the face of technological advancements and a changing political and economic landscape, developing the pipeline to address the skills needs of the engineering sector remains a key challenge.

The engineering footprint

Because the boundaries of what constitutes engineering are often blurred, determining a clear definition of engineering can be difficult, with different organisations historically taking different approaches. To aid consistency, in 2017 the Engineering Council, Royal Academy of Engineering and EngineeringUK reviewed and updated the list of jobs and industries deemed to constitute engineering. The footprint used in this report reflects this revised version.

The Engineering Council, Royal Academy of Engineering and EngineeringUK agreed to standardise the footprint using a binary approach, whereby an industry sector or an occupation is considered to be wholly in or out of the footprint. A set of criteria regarding the level of qualifications and skills deemed to be required for engineering roles was agreed and an extensive review of standard occupational classification (SOC) and standard industrial classification (SIC) lists undertaken.

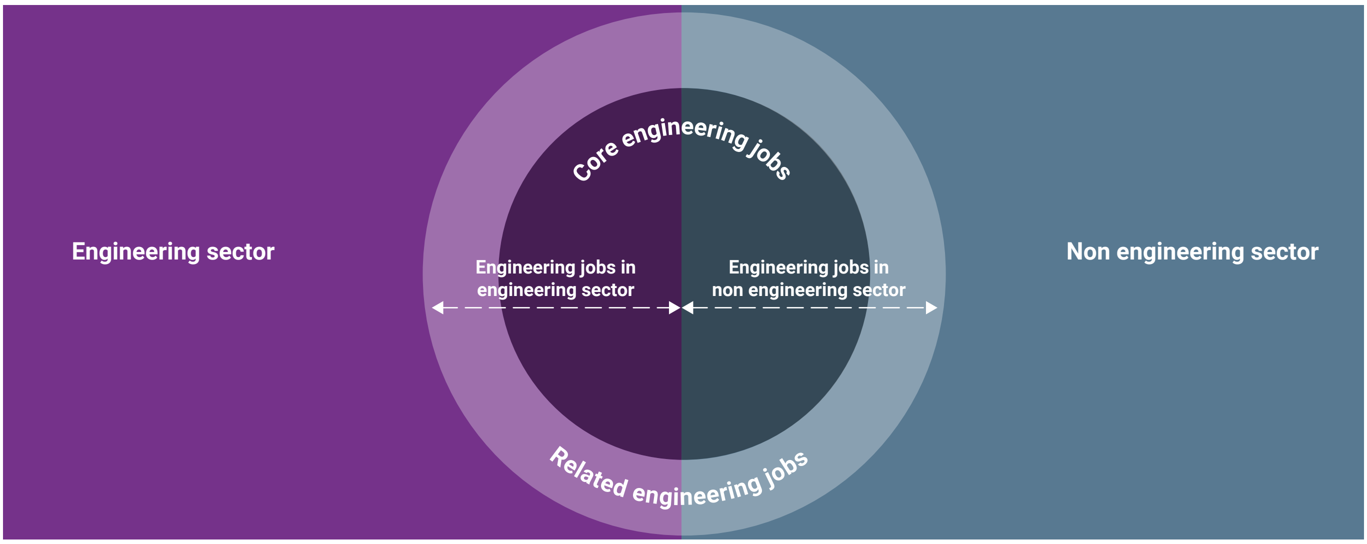
As a result of this review, 10 job titles were removed from the footprint, three were added and four remained with input from external organisations. Fourteen industries were removed from the list of SICs and two were added.

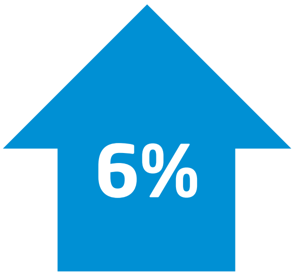
To further improve the precision of the engineering footprint, jobs within the footprint were furthermore classified as **core** or **related**.

Core engineering jobs were defined as engineering roles that require the consistent application of engineering knowledge and skills to execute them effectively. Core engineering jobs include those that are self-evidently engineering: the engineering professionals 'minor' group of civil, mechanical, electrical, electronics, design and development and production and process engineers. The 'core' definition also includes those who require consistent use of engineering competences – for example, a draughtsperson or a welder.

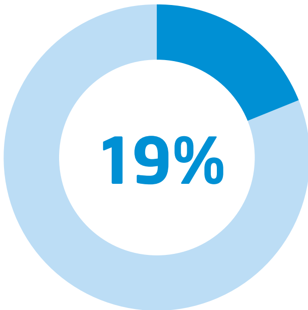
Meanwhile, **related engineering jobs** were defined as those that require a mixed application of engineering knowledge and skill alongside other skill sets, which are often of greater importance to executing the role effectively. An architect is an example of a related engineering occupation.

Revisions to the engineering footprint mean that figures concerning the engineering footprint in this report are not comparable to previous reports – but will enable consistency across the sector going forwards. Where time series are presented in the report, these figures have been recalculated to reflect the revised engineering footprint and are intended to be compared.





rise in number
of UK engineering enterprises between 2015 to 2016



of UK total workforce employed in the engineering sector

Economy

Our findings unequivocally demonstrate engineering is a critical part of the UK economy, both in respect of direct contributions to turnover and employment and its 'multiplier' effect.

Productivity

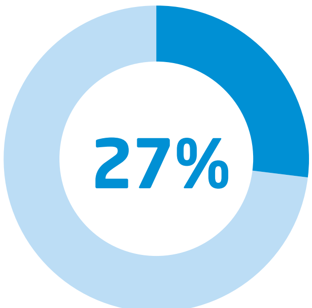
Productivity is a key factor in the standard of living in a national economy, with higher levels meaning improved economic growth and a more prosperous society, with attendant increases in funding for public services. That the UK has seen its productivity decline below that of competitor nations has been a long-standing concern for policy-makers and employers alike.

While the causes of the UK's poor productivity record are contested, it is clear that simply hiring more workers will not be enough to achieve a step change: the productivity of existing employees also needs to be improved, both through investment in technology and skills, and the strengthening of the educational pipeline.

Our findings show that engineering is a crucial sector for raising the UK's productivity levels. Research by the Centre for Economics and Business Research (Cebr) on EngineeringUK's behalf found that the engineering sector had a strong multiplier effect on the economy, generating a further £1.45 Gross Value Added (GVA) for every £1 GVA created directly in the engineering industries. What's more, every additional person employed through engineering activity was projected to create a further 1.74 jobs down the supply chain. Overall, they estimated that the engineering sector generated 25% of the UK's total GDP in 2015 (£420.5 billion).

Manufacturing enterprises within the engineering footprint remain the largest economic contributor of the engineering-based industries, generating £156.1 billion GVA (or 9.3% of the GVA for all industries) in 2015. Indeed, in 2016 almost half of the engineering footprint turnover came from manufacturing (46.5%). But contributions from other engineering sectors were also considerable: the construction industry generated GVA of £62.9 billion, IT, telecommunications and other information service activities £85.4 billion, and mining and quarrying £16.2 billion in 2015.

One of the more visible contributions of engineering to UK productivity is the construction of new national infrastructure. In July 2016, the government major projects portfolio had 143 projects worth over £455 billion. Skills found in the engineering footprint are needed for projects in every category in the portfolio.



of registered enterprises in the UK were in the engineering sector

1.74 jobs
supported by every person employed in engineering
(a multiplier effect of 2.74)

Engineering generated 23%
(£1.23 trillion) of the UK's total turnover

Engineering enterprises

Analysis by the Office of National Statistics for EngineeringUK indicates that just over a quarter (26.9% or 687,575) of the 2.55 million registered enterprises in the UK in 2016 were in the engineering sector, representing a 5.6% growth in terms of the number of enterprises over the previous year. Moreover, this year-on-year growth was observed across all industries within the engineering footprint. Reflecting the growing trend in digitalisation, the information and communication industry saw the largest increase in the number of engineering enterprises, growing by 7.6% over the last year and 40.8% over the last 5 year period.

Employment

Perhaps unsurprisingly, given its share of enterprise, the engineering sector employs a significant proportion of the overall UK workforce. In 2016, just under one in five (18.9% – or 5.66 million) people in the UK workforce were working in at an engineering enterprise. Those working in an engineering enterprise were most commonly employed in manufacturing (42.3%), followed by information and communication (19.5%) and construction (17.2%).

In respect of employment, it is clear some industries, such as information and communications, are expanding while others, notably mining and quarrying, are in decline. Also evident is the strong contribution EU nationals make to the engineering workforce. Data from the Labour Force Survery shows that 7.7% of workers in EngineeringUK sectoral footprint in 2016 were EU nationals, compared with 6.1% in non engineering sectors. And in the first quarter of 2017, EU nationals made up a higher share of the workforce in key engineering-related industries such as manufacturing (11.5%), construction (8.7%) and professional, scientific and technical activities (8.1%) than in the labour force overall (7.3%).

Turnover

The economic contribution of these engineering enterprises to the UK economy is significant. For the financial year March 2015 to March 2016, engineering enterprises registered for VAT and/or PAYE in the UK generated 23.2% (£1.23 trillion) of the UK's £5.3 trillion total turnover from all registered enterprises.

Skills needs

The world of work is changing, with a growing trend in economically developed countries toward an hourglass shaped economy. Technological advances have been key to this transformation, resulting in the expansion of knowledge-intensive services and increased demand for highly skilled labour. As we move further towards an hourglass economy, fuelled by the fourth industrial revolution, there are clear implications for the engineering sector and its skills needs.

In the two decades to 2014, the number of high-skilled jobs in the UK has risen by 2.3 million and, in some sectors, employers are routinely reporting that they are struggling to fill positions. 61% of businesses surveyed in the CBI/Pearson Education and Skills Survey expressed a lack of confidence that there will be enough people available in the future with the necessary skills to fill their high-skilled job vacancies. Shortages in highly skilled labour are expected to be exacerbated by the growth of new industries, some of which scarcely yet exist, emerging from new technologies and knowledge.

Emerging industries

In all engineering related industries, there is a trend towards increased automation and connectivity. Illustrative of this is the tremendous growth observed in information and communication, with turnover generated from the industry reaching £198 billion in 2016, a 23.5% increase from 2011 levels.

Meanwhile, the big data sector continues to grow. It is forecast to contribute £241 billion to UK GDP by 2020 and to create 157,000 new jobs. Going ahead, strong growth is also expected across the architecture and engineering job family, with 3D printing, resource-efficient sustainable production and robotics all seen as strong drivers.

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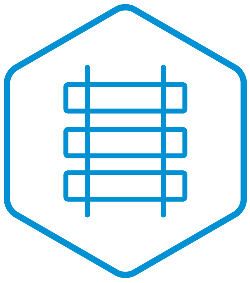
157,000
new jobs in big data
by 2020



7,200 engineering and technical workers needed in high speed rail
by 2020

New technology is likewise transforming the engineering skills needs of construction and rail and road infrastructure. A critical part of Network Rail's railway upgrade plan, the largest modernisation programme since the Victorian era, involves moving from signalling based on fixed blocks of track to block signalling sited within moving trains to increase the capacity of the network. The programme includes High Speed 2 and Crossrail, as well as electrification and station upgrades. Unsurprisingly, these major projects necessitate a significant number of engineers. It is anticipated that an additional 7,200 engineering and technical workers will be needed in high speed rail by 2020.

This accelerating pace of technological, demographic and socio-economic changes is translating to changing needs in the labour. It is critical that the UK prepare itself for these changes. It is our actions today that will determine whether the wave of change brought by the fourth industrial revolution will result in a substantial displacement of workers or in the emergence of new opportunities.

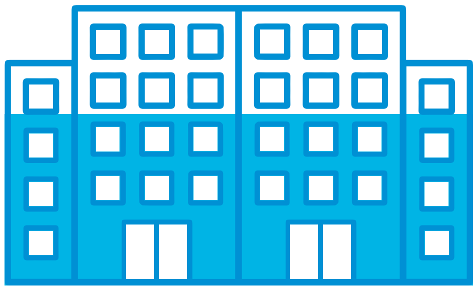
Employment trends

Our analysis shows robust demand for labour, and an outstripping of supply in many engineering industries. April to June 2017 saw the highest vacancy ratio in the labour force since 2001, at 2.6 job vacancies for every 100 filled jobs. Yet this ratio was even higher in some engineering-related industries, including information and communication (3.3) and electricity, gas, steam and air conditioning supply (3.2). Large year-on-year percentage increases in the vacancy ratio were also observed in engineering industries such as mining and quarrying (up 66.7%) and construction (up 27.0%).

It is apparent that the scarcity of candidates, together with rising demand, has had a positive knock-on effect on engineers' salaries. Our analysis found that the median salaries of full time employees working in engineering occupations in 2016 – ranging between £32,987 for environment professionals and £47,394 for electronic engineers – compared very favourably to the overall average of £28,195.

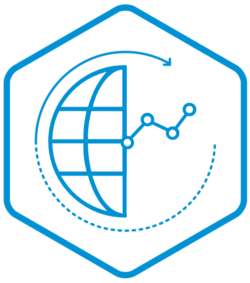
However, while nominal wages are rising, real wages appear to be stagnant. Economists have speculated that this wage stagnation is both a consequence of the UK's low labour productivity and the inflation it has experienced since the country's decision to leave the EU.

Within this context, the UK's decision to leave the EU brings significant uncertainty to the sector. While the economy has not suffered as much as the Treasury predicted it would following the UK's decision to leave the EU, there are signs that this resilience is declining because of the falling pound and rising prices. There is also evidence to suggest the EU referendum result has reduced net migration numbers.



61% of businesses were not confident there will be enough people with the skills to fill their high-skilled job vacancies

124,000
engineers and technicians with core engineering skills required per year



79,000
engineering-related roles to arise per year

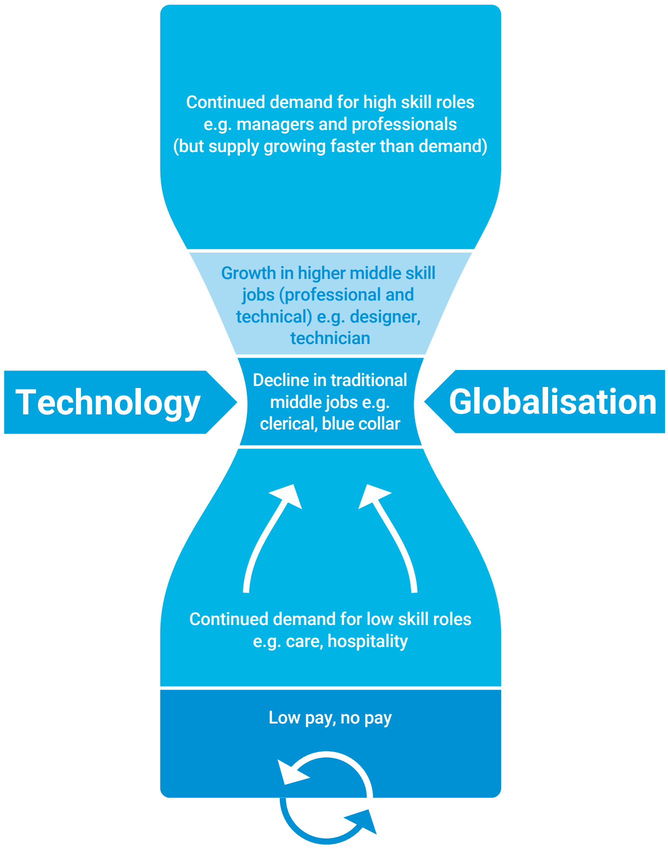
Demand forecasts

Across the UK and other developed nations, there is an increasing move towards an 'hourglass' economy, with rising demand for both high and low skilled labour. It is clear from our analysis that the engineering sector is no exception to this trend. Moreover, there is considerable demand for engineering skills outside of industries traditionally deemed to be engineering. Given the engineering talent currently coming out of the educational pipeline, we estimate there is an acute shortfall of engineering skills – and that this will continue without concerted action.

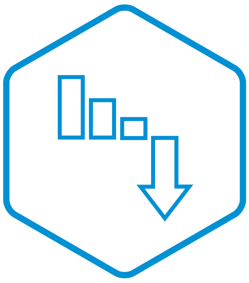
The hourglass economy

The increasing fusion between the digital, physical, and biological, has driven – and will continue to drive – already strong demand for highly skilled labour, especially in the area of STEM. Net requirement projections from Working Futures 2014-2024 indicate that by 2024, 54.1% of the workforce will require Level 4+ qualifications. This compares with 41.1% in 2014.

Going forward, it is also expected that demand for lower skilled jobs will increase. This is because while the semi-routine nature of many middle-skilled occupations are vulnerable to automation, traditionally low-skilled occupations often involve skills not readily automated. Such roles include those in health and social care, which are forecasted to increase alongside the needs of an ageing population. This 'hourglass economy' is expected to hold for the UK well into the future.



Altogether, 203,000 people with Level 3+ engineering skills will be needed every year to meet demand through to 2024



Annual shortfall of up to 59,000 engineering graduates and technicians to fill core engineering roles

Demand forecasts for engineering skills

A bespoke extension of *Working Futures* undertaken by Warwick Institute for Employment Studies on EngineeringUK's behalf estimates that between 2014 and 2024, 1,240,000 graduate and technician core engineering jobs will arise across all industries as a result of both replacement demand (i.e. the result of people leaving the labour force) and expansion demand (i.e. new jobs). Assuming that this is uniformly distributed across the ten years, this translates to a need to fill 124,000 Level 3+ core engineering roles every year.

Alongside this, we anticipate an additional annual requirement for 79,000 "related" roles requiring a mixed application of engineering knowledge and skill alongside other skill sets. Altogether, this means 203,000 people with Level 3+ engineering skills are required per year to meet expected demand.

Of this total annual net requirement, 57.7% is expected to arise in the engineering sector. That 42.3% of the projected requirement for Level 3+ engineering occupations is expected to arise outside of the engineering sector attests to the ubiquity of engineering skills required across industry.

Estimated shortfall

It is evident from our analysis that there is a critical shortfall in engineering skills across qualification levels and core and related engineering occupations.

Given the supply of engineering talent coming from the educational pipeline through apprenticeships and higher education, we estimate there to be a shortfall of between 37,000 to 59,000 in meeting an annual demand for 124,000 core engineering roles requiring Level 3+ skills. Within this, we expect a graduate-level shortfall of at least 22,000 per year.

Altogether – when looking at total demand for Level 3+ engineering skills across core and related engineering roles more broadly – we estimate the annual shortfall to be at least 83,000, and up to 110,000.

Labour force movement

It is accepted that the fulfilment of net recuitment requirements (whether from replacement or expansion demand) does not have to be met entirely from new entrants to the workforce from education. For example, some economically inactive people may transition back to the labour market. There is also movement within the labour force to and from engineering enterprises and occupations.

However, analysis into the extent to which there is occupational mobility to and from the engineering sector, undertaken by the Institute for Employment Studies on EngineeringUK's behalf, has concluded that these do not materially impact the engineering skills shortfall.

Using Labour Force Survey (LFS) data for the period 2006 to 2016, IES concluded that annual flows into and out of the engineering sector over the last decade were broadly net neutral. This has two implications. Firstly, our engineering skills shortfall estimates are robust against the omission of net intersectoral mobility. Secondly, while there is potential to reduce the shortfall by attracting more workers from other sectors and improving retention, so far annual net inflows into the engineering sector have been too small to make a tangible difference.

Changes and comparability

Both demand and shortfall figures presented in this report are not directly comparable to previous editions. This is due to the use of a revised engineering footprint, which has resulted in a narrowing of what is considered to be engineering, alongside refinement in the demand and supply methodology, such as the inclusion of forecasted demand arising in the non engineering sector. These changes aim to foster greater consistency in the sector going forward, and take into account the considerable need for engineering skills outside of industries traditionally deemed to be engineering.

Careers strategy
published in December 2017

New assessment system for GCSEs
in England phased in during summer 2017

Government strategies and policy initiatives

Population projections from the Office of National Statistics indicate that in the next 5 years, there will be considerable increases in the number of 12 to 16 year olds. Over the next 20 years, all age groups are expected to grow, especially those of secondary school age. This is encouraging for the potential engineering talent pool.

The extent to which this potential is harnessed will be dependent on the educational decisions young people make now and into the future. The government has introduced a number of strategies and policy initiatives, many of which are intended to address skills shortage and employability concerns. These are steps in the right direction, but it is essential that progress toward these stated objectives is carefully monitored over time.

Government strategies

The issue of the engineering skills gap continues to have a high profile across government, with significant investment and policy initiatives aimed at increasing the take up of STEM subjects, the status of technical education and the supply of key skills.

The industrial strategy, published in November 2017, emphasised the important role of education in driving skills, economic growth and productivity and the need to identify and address sector-specific skills gaps to support this objective.

The following month, the Department for Education published the long awaited careers strategy for England, which set out a plan to improve careers advice and guidance provision in England. This is a welcome initiative with a clear timetable for action, allowing the sector to hold the government to account for progress.

The government's vision for a revised technical education and apprenticeships landscape, its Social Mobility Action Plan and its commitments to raising the take up and quality of STEM learning through the industrial strategy is intended to bring about the 'skills revolution' this country needs, and safeguard investment in education and skills from the uncertainty surrounding Brexit.

Devolved administrations

In parallel to this, STEM education was the focus of a number of flagship initiatives across the devolved nations in 2017. Scotland saw the launch of a five year STEM Education and Training Strategy in October 2017. One of its key areas of intervention is the recruitment and retention of STEM teachers in schools, which has been a significant issue in recent years. Likewise, last summer the Welsh government announced a £3.2 million drive to improve how maths is taught in Welsh schools.

GCSE and A-level assessment

Summer 2017 saw the first GCSE maths and English results issued in England using a new assessment system with a 9 to 1 grading system, with the same change to sciences planned for summer 2018. At the same time the first awards of the new 'linear' A levels in biology, chemistry, computer science, and physics, where assessment is mainly by examination at the end of the course, were made.

Post-16 Skills Plan and apprenticeship reforms

Major changes to the technical education are underway. This has largely been driven by recognition of the skills shortage and perceived flaws within the current system, including the low qualifications value of many apprenticeships and a complexity that learners find difficult to navigate.

Some of the legal basis for these changes is provided by the Technical and Further Education Act, which received royal assent in 2017. The Act includes the so-called "Baker clause" (arising from an amendment proposed by former education secretary Lord Baker), which from January 2018 requires schools to give further education providers opportunities to inform pupils about the qualifications they offer, and publish a policy statement outlining how those providers can access their pupils.

Under the Post-16 Skills Plan, the government has proposed a common framework for 15 technical education routes for college-based and employment-based training. The intention is for there to be clearer delineation between academic and technical education, with learners working towards A-levels or T-levels, and apprentices able to transition between the two. An equalities impact assessment undertaken by the government suggests that there may be diversity issues arising from this approach, with those taking a technical route more likely to be male, of Caribbean ethnicity, have special

Apprenticeship levy introduced
in April 2017

Higher Education and Research Act
received royal assent in April 2017

educational needs and/or a disability, or eligible for free school meals. Ongoing monitoring of the policy and its consequences for young people is therefore important.

This plan seeks to build on existing apprenticeship reforms already underway in England, in the form of new apprenticeship standards, degree apprenticeships, and an apprenticeship levy on employers.

Since 2014, the Institute for Apprenticeships, which has responsibility for delivering high quality apprenticeship standards and assessment plans for England, has been working with groups of 'trailblazer' employers to develop new apprenticeship standards for different job roles. As of summer 2017, 160 new employer-led apprenticeship standards were ready for delivery, 83 in the engineering footprint.

In April 2017, the apprenticeship levy came into force, requiring companies with a wage bill exceeding £3 million to fund apprenticeships, in part to meet the government's target of 3 million apprenticeship starts in England by 2020. Though it is early days, some have expressed concerns that this could result in a compromise in quality. Further, fears of "relabelling" existing training to claim back levy spend appear to be credible from evidence gathered by the CBI and Pearson.

Increasingly, the government has focused on apprenticeships at higher qualification levels, amid concerns that much of the initial growth in apprenticeship activity has been at low levels. It is already evident that degree apprenticeships – which combine aspects of both higher and vocational education – are attractive to HE institutions, with many investing considerable energy and resources into developing their provision. Many of the new degree apprenticeships on offer are engineering-focused, including in aerospace, automotive, construction, digital industries, electronic systems and nuclear, and lead to professional registration.

Higher Education and Research Act

There has been considerable change to the higher education landscape in recent years, with reductions in public funding across the UK and increasing undergraduate tuition fees in England.

2017 saw the passage of the Higher Education and Research Act (HERA), deepening the market approach already in place. Described by Wonkhe as "the most important legislation for the sector in 25 years", the Act aims to create more competition and choice, boost productivity in the economy, ensure students receive value for money and strengthen the UK's research and innovation sector.

To achieve this, HERA made way for a new regulator and funding council for universities called the Office for Students, which will hold the statutory responsibility for standards and quality. Notably, the Office for Students will oversee the Teaching Excellence Framework (TEF), an assessment of teaching quality, which includes the 'employability' of graduates as one of its assessment criteria. It is hoped TEF will contribute to addressing skills shortages, especially in high skilled STEM areas, where concerns have been expressed around some graduates not being sufficiently 'work ready'. However, concerns around the metrics used by TEF to measure employability have been raised in the sector.

The Act also brought the seven Research Councils, Innovate UK and the research functions of the Higher Education Funding Council for England (HEFCE) under a single body called UK Research and Innovation (UKRI) and created Research England, a new body that, among other things, may make provisions for universities to charge higher annual fees for 'accelerated degrees.'

10% **decrease in GCSE** entries for biology, chemistry and physics between 2012 and 2017

7% **increase in engineering-related** apprenticeship starts from previous year (England, 2015/16)

Trends in the educational pipeline

The largest flow of newly skilled talent into the engineering workforce comes directly from education. Between each educational stage, there is potential for 'leakage' from the pipeline, as individuals make voluntary decisions about their progression.

While trends in STEM education are broadly positive, developing the pipeline to address the skills shortage will continue to be a challenge for the engineering community. Gender representation, in particular, is a key concern.

Secondary school

GCSE entries are a major indicator of skills at the beginning of the engineering talent pipeline. Analysis of GCSE entries over the last five year period present a mixed picture, but often show declining entry numbers in STEM and, particularly for technology subjects, skewed towards entries by boys.

Entries for biology, chemistry and physics between 2012 and 2017 decreased by around 10%, for example, amid a backdrop of entries across all subjects increasing by 4.2% in the same period. Notably, entries for science, which as a subject previously had the second highest number of entries, have dropped by over 46% over the last five years. While in this time entries in additional science have increased (29.8%), it has done so at a lower rate than the decline observed in science.

At A-Level, entry numbers have encouragingly increased in mathematics, chemistry and physics over the last five years. However, that STEM subject pass rates remain significantly below average is a concern. With the exception of further mathematics (88.2%) and mathematics (80.3%), A* to C pass rates for all STEM subjects were below the all subject average of 77.4% in 2017. Furthermore, A* to C pass rates have declined in all STEM subjects (except computing) by at least 1 percentage point over the last 5 years, even as overall pass rates have increased by 0.8 percentage points.

Apprenticeships

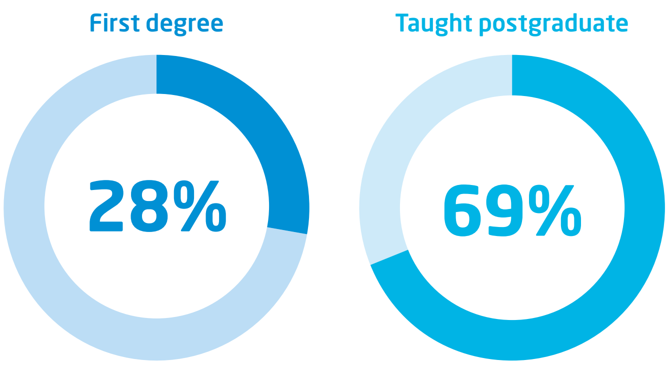
Employer participation in apprenticeships has continued to increase. 262,500 employers in England employed apprentices in the academic year starting 2015, a 4.5% increase in the number who did so the previous year.

Encouragingly, engineering-related apprenticeships also appear to have grown in popularity. In England, the number of engineering-related apprenticeships starts in the academic year 2015 to 2016 increased by 7.4% over the year before, and in Scotland by 6.8%. The year-on-year increase was even higher in Wales, at 7.8%.

In total, 129,059 people started engineering-related apprenticeships across England, Scotland and Wales in 2015 to 2016, and 73,109 achieved success in the same year. Although apprenticeship figures are not disaggregated by start or achievement in Northern Ireland, the available data indicates 4,146 people were on engineering-related apprenticeships in 2016.

While these figures are promising, initial data from 2017 suggest apprenticeship starts are dropping. This decline has coincided with the introduction of the apprenticeship levy.

It is furthermore clear that more needs to be done to raise awareness and understanding of apprenticeships among young people. In the Engineering Brand Monitor 2017, 58% of 11



28% of students in engineering-related first degree courses and 69% students in postgraduate taught courses were not from the UK

Proportion female

50%	22%	16%	8%
GCSE physics entrants	A level physics entrants	Engineering and technology first degree entrants	Engineering apprenticeship starts (England only)

to 14 year olds surveyed indicated they knew almost nothing or just a little about what apprentices do and the different types of apprenticeships available. Understanding was similarly low among parents surveyed, with only 46% indicating knowledge of what apprentices do and 55% about the different types of apprenticeships available.

Further education

The national colleges and the institutes of technology are the latest of a number of vocationally related institute types and policy initiatives introduced by government in an effort to increase the quality and provision of higher-level technical education across the country. Both are so new that it is too early to make any judgements as to their impact on the FE landscape and supply of skilled people to their respective industry sectors.

As part of the response to the Sainsbury Review, the government announced it would invest nearly £80 million in May 2016 to create employer-led national colleges in 5 areas. The National Colleges for High Speed Rail (with hubs in Birmingham and Doncaster) and for Nuclear (with hubs in Somerset and Cumbria) started their first courses in late 2017. The National College for Onshore Oil and Gas was intended to open at the same time but has been delayed. Institutes of technology, which may be based at existing further education colleges, are expected to open in 2018.

Higher education

There are widespread concerns that the UK's decision to leave the EU will make the higher education (HE) sector less attractive to international staff and students, and make it harder to access research funding and collaboration opportunities. Together, these could negatively affect the quality of UK HE teaching and research, particularly in engineering, which has a high proportion of international students. This is most apparent at taught and research postgraduate levels, where international students make up 68.9% and 61.1% of engineering and technology students respectively; within some engineering disciplines, this proportion exceeds 80%. It is possible that the continuation of these courses – and the supply of engineering and technology skills at level 4+ – may be affected by changes to the mobility of international students.

The final Brexit agreement with the EU is uncertain, but for universities there is a very real possibility they will be less able to recruit EU students and attract EU research funding beyond 2020. This would reduce income at a time when many face multiple pressures, especially in high-cost subjects. The debate on immigration and the rhetoric around Brexit may also impact on the views of those international students and researchers considering the UK. In light of these changes, institutions will need to work hard to ensure that the UK remains a destination of choice for students and staff alike.

In terms of trends, total student numbers have decreased over the last five years for which data is available, with the biggest fall in the year tuition fee arrangements in England changed. However, in the academic year 2015 to 2016, there was a small year-on-year increase in HE student enrolments for the first time since 2010 to 2011.

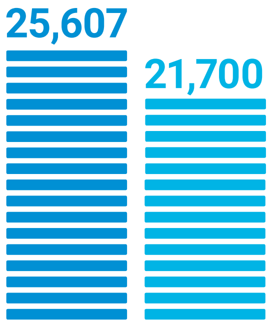
There was a 1% increase in the number of HE students studying engineering and technology in 2015 to 2016 compared with the previous year, taking the total to 163,255. This was due largely to a rise in entrants at first degree level. It is the third consecutive year in which numbers have increased, whereas overall HE student numbers have fallen in two of those years.

However, in the academic year 2015 to 2016, fewer students started both taught and research postgraduate engineering and technology courses, falling 3.5% and 9.2% on the previous year to 16,570 (taught) and 4,460 (research).

Women comprised just 16% of first degree in engineering and technology students in 2015 to 2016, compared with 50.1% of STEM first degree entrants and 56.1% of first degree entrants overall. They were better represented at postgraduate level, making up a quarter of both taught and research students. This suggests they are more likely to pursue postgraduate study than their male peers. Nevertheless, the fact remains that women are severely underrepresented in engineering and technology across all levels of HE, including at postgraduate levels.

62%

of engineering and technology graduates entered full time employment, compared with 56% of all graduates



The mean starting salary for engineering and technology graduates was 18% higher than for graduates overall

Transition to employment

Employment prospects for engineering and technology students are strong, with graduates having better chances of both getting a full-time job and earning higher starting salaries than other graduates. However, it is evident that there are ethnic and gender disparities in graduate outcomes with respect to destination and pay. Furthermore, work readiness of graduates remains a concern among employers.

Graduates' employment prospects

In terms of finding full time employment, UK domiciled first degree graduates who had studied engineering and technology full time fare better than average. In 2015 to 2016, 62.0% entered full time employment, compared with 56.1% of all graduates, with fewer than the all subject average entering part time work (8.0%) or work and further study (2.8%). Employment outcomes for full time UK domiciled engineering and technology postgraduates are better still: 63.5% of taught postgraduates and 80.7% of research postgraduates entered full time employment in 2015 to 2016.

It is also evident that engineering and technology graduates have strong earnings potential. With a mean starting salary of £25,607, engineering and technology first degree graduates earned 18.0% more than the average for a graduate in the six months after leaving university. Only graduates in medicine and dentistry and veterinary science earned higher starting salaries. Likewise, mean salaries for employed engineering and technology postgraduate taught graduates (£27,623) were 10.5% higher than the overall average for UK full-time domiciled taught postgraduates (£25,002). The same was true of UK full-time doctoral level graduates, who earned 3.1% more than the all subject average of £33,092.

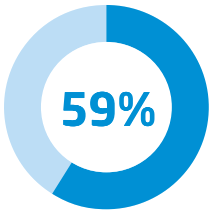
Communicating the financial opportunities an engineering and technology degree affords is key to improving the engineering talent pipeline. As findings from our Engineering Brand Monitor show, while more than three in five young people aged 11-19 thought that engineers were 'well paid,' only 20% were able to accurately guess the broad salary range for the average graduate engineer, with nearly three in five indicating a salary band considerably lower. This is significant, as we found that among respondents, pay was one of the most important factors when deciding upon a career – second only to it being something they were interested in.

There is, however, a clear distinction between employment and employability. Both the Wakeham and Shadbolt reviews presented evidence of employers being dissatisfied with the level of graduates' 'soft' skills or 'work readiness'. Myriad research into employer requirements support these assertions and indicate graduates would benefit from greater opportunities in the curriculum to develop business skills and gain real world work experience.

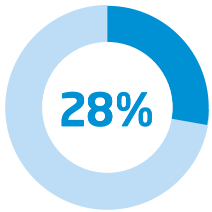
Furthermore, there are marked differences in destinations between white and BME leavers. Our analysis found that a much larger proportion of white engineering and technology graduates entered full time employment (65.6%) within six months of graduating in the academic year 2015 to 2016 than those of ethnic minority background (48.6%). Although this trend can be observed among UK domiciled leavers of different ethnicities who studied full time in general, these differences were more pronounced among engineering and technology graduates.

There are likewise differences in outcomes by gender. While full time employment rates are similar among male and female engineering and technology graduates, larger proportions of men enter engineering occupations than women. Among engineering and technology graduates who found employment six months after graduation, 35.7% of women were in roles that were neither engineering-related or within the sector. This compares to 29.6% of male engineering and technology graduates.

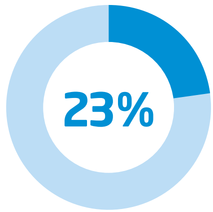
These figures are concerning, at the very least indicating female and BME graduates are 'leaking' from the pipeline. Further investigation is needed to look at whether these gender and ethnicity gaps come from engineering graduates' own choice of career direction or are down to factors in the occupational recruitment process.



of 11 to 14 year olds surveyed would consider engineering, compared with 39% of 16 to 19 year olds



of 11 to 14 year olds surveyed have taken part in a STEM careers activity in the last year



of teachers who qualified in England between 2011 and 2015 had left the profession by 2016

Harnessing the talent pool

As our EBM findings – and, more broadly, this report – highlight, if we are to address the severe skills shortage in engineering, we must effectively harness the talent pool of young people. To be successful, this endeavour must be extensive and inclusive: working across the education, government, and industry sectors; engaging with young people, teachers, and parents; and employing a variety of activities to engage young people of all backgrounds. While ultimately it is up to the young person to decide whether they want to pursue engineering, there is much work we can do as a community to ensure young people are well informed when making their educational and career decisions.

Perceptions and attitudes toward engineering

There are signs that young people's interest in the engineering profession is growing. According to EngineeringUK's Engineering Brand Monitor Survey (EBM), the proportion of young people aged 11 to 19 who would consider a career in engineering has risen from 40% in 2013 to 51% in 2017.

However, the older pupils get, the less likely they are to consider a career in engineering: 39% of 16 to 19 year olds in 2017 would consider engineering, compared with 59% of 11 to 14 year olds. While this may partly be due to older pupils having clearer career aspirations and solidifying their plans, it also confirms that sustaining young people's interest as they progress through secondary education is a key challenge.

Evidence also suggests that there is more work to be done in informing young people, especially girls, about what a career in engineering can entail. Our EBM results indicate that at every age, boys are far more likely to consider a career in engineering than girls. The findings further suggest that pupils across all ages are less likely to understand engineering careers than science or technology careers. Evidence from the ASPIRES project supports this, indicating that young people often have poorly formulated views of what engineering jobs actually entail.

There is also more to do to improve the image of the profession so that more young people see it as desirable. Adults and teachers surveyed in the EBM were more likely to view a career in engineering as desirable for their children or for young people than young people themselves: nearly 7 in 10 adults and 8 in 10 teachers said so, compared with 44% of pupils (16 to 19 year olds).

Teacher shortages

Though STEM teacher recruitment and retention has been a longstanding problem, it has become acute in recent years. Pupil numbers have grown by nearly half a million between 2011 and 2016, but the number of STEM specialist teachers has remained largely stagnant since 2015.

2017 marked the fifth consecutive year in England for which recruitment targets for trainee teachers were missed, with the shortfall particularly pronounced in STEM subjects. In the year 2017 to 2018, there was an estimated shortfall of 2,188 STEM trainee teachers against the DfE teacher supply model target. Only 33.4% of design and technology places were filled in England in that academic year, as were 68.1% of physics and 78.9% of maths positions.

Teacher retention has also not seen improvement. Of the 117,000 teachers who qualified in England between 2011 and 2015, 23% had left the profession during that time. Moreover, the proportion of those leaving for reasons other than retirement has grown from 68% in 2011 to 75% in 2014. In particular, retention of newly qualified science teachers is a concern, with recent research suggesting that they are 20% more likely to leave the profession within their first five years than similar newly qualified non-science teachers.

These shortfalls persist despite many attempts by governments across the UK to address these issues. It is therefore crucial that the government, engineering industry, and education sector work together on innovative approaches to incentivise talent into the STEM teaching profession, and to improve retention.

Current careers provision

Access to engineering careers requires a well-functioning system of careers education and guidance. However, careers provision in England remains inconsistent and can miss those who need it most.

In a national survey of over 13,000 year 11 students (aged 15 to 16 years) in England, less than two-thirds indicated that they had received careers-related education. The study also found careers provision to be "patterned by social injustices", with girls, minority ethnic, working class and lower-attaining students less likely to receive careers education than their peers. Encouragingly, our EBM results suggest that the proportion of 11 to 14 year olds who have taken part in a STEM careers activity is rising, standing at 28% in 2017 compared with 23% in 2016.

Female
47% of UK workforce
12% of engineers and technicians

BME
12% of UK workforce
8% of engineers and technicians

There is evidence that schools often struggle to differentiate between the offers in a very crowded market and to identify the activities that would be most appropriate and impactful in their setting. In fact, the Royal Academy of Engineering (RAEng) estimates more than 600 UK organisations run STEM engagement initiatives directed at schools. Given the amount of effort and resources directed to delivering STEM inspiration and enrichment initiatives, there is an urgent need to identify which are most impactful so that resources are appropriately targeted and evidence-based. In this respect, the Department for Education's recently published careers strategy is a welcome move.

Diversity

Tackling diversity issues at every stage of the educational pipeline and in the profession needs to be a key priority for the engineering community. Employers in the engineering sector have a very significant role to play in promoting equality and diversity, working with schools, universities and on their own.

It is evident the engineering workforce does not reflect the diversity of the overall working population, particularly in respect of gender. While women comprised 46.9% of the overall UK workforce in 2016, they only made up 20.5% of those working in engineering sector. This proportion is even lower when considering just those working in core and related engineering roles, at 12.0%. Likewise, only 8.1% of workers in the engineering sector were from ethnic minority groups, compared with 12.7% in non-engineering sectors, and 12.2% of the broader population.

Our report finds strong evidence that girls and people from BME communities are being lost at different points within the educational pipeline. It is clear that these 'leakages' ultimately contribute to the underrepresentation of these groups in the engineering profession.

For example, at secondary school level, only 27.1% of girls' A level entries in 2017 were in STEM subjects, compared with 45.6% of boys' entries. Gender underrepresentation is particularly pronounced within A-level computing and physics, where girls comprised just 9.8% and 21.5% of entries, respectively, in 2017.

Diversity also remains a concern in technical education. Just 7.5% of engineering related apprenticeship achievements in England and 3.4% in Scotland were completed by women in 2015 to 2016. And while 10.3% of people achieving apprenticeships in England overall were from BME backgrounds – the highest ever recorded, the proportion lagged behind in engineering-related sector subjects, at 6.8%.

Nevertheless, there are signs that female representation is slightly improving in engineering degree courses. For example, the proportion of women entering first degree undergraduate engineering and technology subjects increased from 15.1% in the academic year starting in 2014 to 16.0% the following year. However, out of all subject areas, engineering and technology had the second lowest proportion of first degree entrants who were women in the academic year starting in 2015 – only computer science had a lower proportion, at 14.9%. This contrasts with the number of women starting STEM first degrees (50.1%) and first degrees overall (56.1%).

Furthermore, although students from a BME background are well represented within higher education (where they represent 25% of engineering students), there are clear degree attainment gaps, with outcomes for BME first degree engineering and technology qualifiers consistently lower on average than white qualifiers. Four in five (80.4%) of white students obtained a 'good' (first or upper second class) degree in engineering and technology in the academic year starting 2015, compared with 68.5% of BME qualifiers.

There are also equality issues apparent in labour market outcomes, with lower rates of female and BME engineering and technology graduates going on to engineering-related roles or working within the engineering sector than their male and white peers. Likewise, gender pay gaps are evident among those working in engineering occupations, with the average full time salary higher for women than for men in only two SOC core engineering occupational groups (electrical engineers and electrical and electronic trades not elsewhere classified). However, our analysis suggests that although there is a gender pay gap in engineering, it is generally smaller than observed more widely in the labour force.

While discussion on social mobility in this report is limited, the growing focus on social mobility in the wider policy environment is good news for STEM skills shortages, as this may translate into the talents of more young people being recognised and used. Growth in demand for STEM skills likewise represents a significant opportunity to promote greater overall social mobility in the UK.

Challenges and recommendations

If modern engineering is to continue to provide its enormous economic and social contributions to the United Kingdom, it is of critical importance that the engineering community work alongside the government and educational sector to address the skills shortage.

Challenges

In the context of strong demand for engineering skills and a changing political and economic landscape, it is essential that we encourage young people to study STEM subjects and pursue engineering-related qualifications. Our report highlights that while there has been positive movement, there continue to be significant challenges to addressing the skills shortage in engineering:

- **Too few STEM teachers.** Recruitment and retention of STEM specialist teachers, who have a vital role in shaping the aspirations and career trajectories of young people, remains a key issue.
- **Limited access to STEM careers activity.** Access to inspirational engineering-focused engagement activities, which can help to ensure young people experience real life applications of engineering and make well-informed subject and career decisions, is uneven.
- **Too many initiatives.** Schools often struggle to identify which STEM engagement initiatives are most appropriate and impactful for their setting.
- **Too few women becoming engineers.** Women are underrepresented in every stage of the educational pipeline into engineering and among those working in the profession.
- **Too little home grown talent.** Our current reliance on international students leaves the engineering talent pipeline vulnerable to changes that could occur once the UK leaves the EU.
- **Too little understanding of apprenticeships.** There is a need to increase awareness and improve perceptions of apprenticeships as a worthy alternative to a university education – and to ensure the apprenticeships on offer are of high quality.

Recommendations

There are a number of specific actions that we recommend taking to tackle these challenges. Notably, these require the involvement of not only the engineering and STEM outreach communities, but also the education sector and the government. Closer collaboration between these four groups is key if we are to ensure young people experience real life applications of engineering, are well-informed of the many opportunities a career in the profession can provide – and ultimately, the shortage in engineering skills is addressed.

1. Streamline the STEM outreach landscape. The engineering and STEM outreach communities need to make it simpler for schools to connect with employers and other providers to access high quality, engineering focused STEM engagement activity. The re-positioning of the Tomorrow's Engineers programme as the go to place for such activity will address this and we encourage the whole community to get behind this work.

2. Understand what works. The engineering and STEM outreach communities should develop a better understanding of what engineering-focused careers interventions work. Strengthening evaluation of existing programmes and sharing good practice can help to ensure we direct our resources most effectively.

3. Address the STEM teacher shortage. The government should work with the engineering and education communities to increase the supply and retention of specialist STEM teachers. This has been a long-standing issue, and one that requires innovative approaches to address.

4. Safeguard against the potential negative implications of Brexit. The government must ensure the UK's exit from the European Union does not exacerbate the engineering skills shortage. In particular, it is vital that the higher education sector maintain its status as world-class and welcoming to talent across the world.

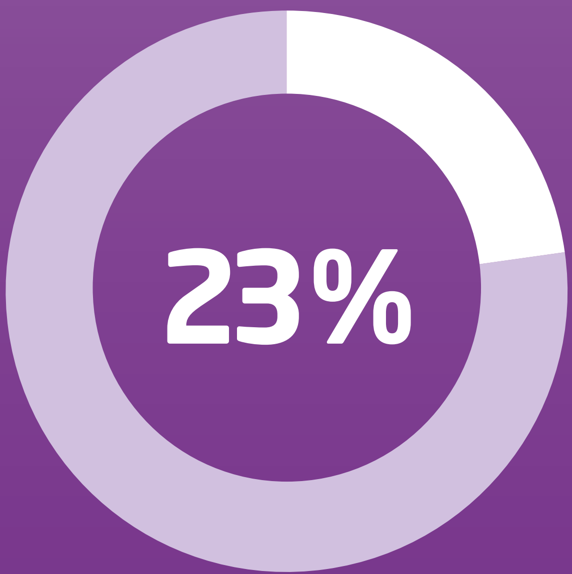
5. Ensure apprenticeships are of high quality. Engineering employers and the government need to increase the supply of high quality apprenticeships. Further work is required to raise awareness of apprenticeships among young people and their influencers. In addition, we recommend that the apprenticeship levy be reviewed to ensure it is having its intended effect.

6. Raise understanding and awareness of engineering. The engineering community should ensure young people have a full understanding of the excitement and variety a career in engineering offers, and the potential contribution they can make as an engineer. The Year of Engineering and This is Engineering campaigns are key opportunities to showcase the profession to a new generation, and ones that need to be embraced and supported by the community.

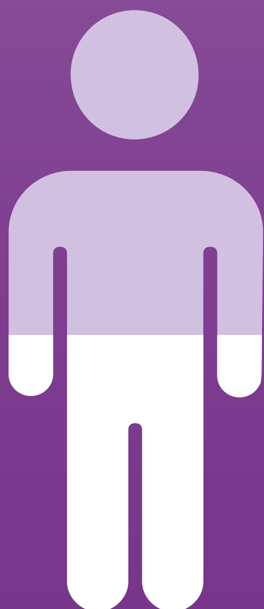
7. Improve diversity and inclusion. The engineering community should improve its diversity and inclusion record. We need to better understand the barriers for women, black and minority ethnic communities and people from disadvantaged backgrounds to pursue pathways into, and careers in, engineering.

The engineering sector

Engineering has a vital role in driving UK innovation and economic growth.



of the UK's turnover was generated by the engineering sector (£1.23 trillion)



Concerted effort is needed to address the engineering skills shortage.

46%

of engineering employers surveyed by the IET reported recruitment difficulties

1 - Engineering in context

In 2017, the UK had the third lowest rate of productivity among the G7 countries

An industrial strategy, published in November 2017, emphasised the need to address skills gaps to drive economic growth and productivity

Key points

Engineering has a key role in driving economic growth and productivity, generating 23.2% of the UK's 5.3 trillion turnover and employing 18.9% of the UK labour force. The sector is also integral to the country's ability to innovate, attract investment, and develop infrastructure. As such, it is a crucial sector for raising the UK's productivity levels.

Skills shortages and the productivity puzzle

The UK's productivity gap with other advanced economies has been a long-standing concern for policy-makers and is a key driver for the government's industrial strategy launched in November 2017. While the causes of the UK's poor productivity record since 2007 are contested, it is clear that simply hiring more workers will not be enough to achieve a step change: the productivity of existing employees also needs to be improved, both through investment in technology and in skills.

Key to addressing the productivity puzzle, then, is increasing skills among the labour force – but this has proven challenging within a wider context of skills shortages, and a growing trend toward a so-called hourglass economy. For example, the latest Skills and Demand in Industry Survey conducted by the Institution of Engineering and Technology (IET) in 2017 suggests that 46% of participating employers reported recruitment difficulties due a lack of suitably skilled candidates, and a quarter noted skills gaps or limitations in their existing workforces. These issues may also be exacerbated by the UK's exit from the European Union, given the engineering sector's particularly mobile workforce and reliance of higher education on international staff and students.

Government strategies

In the context of this changing political and economic landscape, the engineering skills gap continues to have a high profile in across the UK governments, with significant investment in developing STEM skills and numerous policy initiatives aimed at increasing the take up of STEM subjects, the status of technical education and the supply of engineers.

The industrial strategy was published in November 2017 and was welcomed by the engineering sector. This emphasised the important role of education in driving skills, economic growth and productivity and the need to identify and address sector-specific skills gaps to support this objective. It will be important to monitor its implementation.

The strategy provides a framework for concerted action across government departments to support the economy, including through reform and policy initiatives to improve STEM education and skills. These include:

- the Department for Education (DfE)'s Social Mobility Action plan, which has an ambition to provide high quality post-16 education choices for all young people and improve equality of opportunity in the system through more investment and transparency, particularly in higher education
- the DfE's long-awaited careers strategy, which was published in December 2017 and set out a plan to improve careers advice and guidance provision across England
- the DfE's technical education and apprenticeship reforms since 2015, designed to put vocational education on an equal footing with the UK's world class higher education system. These include the introduction of T-levels, degree apprenticeships and measures to address the issues identified by the Sainsbury review of technical education, as reflected in the DfE's Post-16 Skills Plan
- the Department for Business, Energy and Industrial Strategy's implementation of the Higher Education and Research Act 2017, which marks the most radical regulatory change to higher education of this century
- the Department for Transport (DfT)'s Transport Infrastructure Skills Strategy
- devolution of powers from London and the introduction of metro mayors by the Ministry of Housing, Communities and Local Government, which may result in increased local decision-making and control over skills, training and apprenticeship services.

In parallel to this, STEM education was the focus of a number of flagship initiatives across the devolved nations in 2017. For example, Scotland saw the launch of a five year STEM Education and Training Strategy in October 2017. One of its key areas of intervention is the recruitment and retention of STEM teachers in schools, which has been a significant issue in recent years. Likewise, last summer the Welsh government announced a £3.2 million drive to improve how maths is taught in Welsh schools.

These are steps in the right direction, but it is essential that progress toward these stated objectives is carefully monitored over time.

1.1 – Introduction

Engineering has a key role in driving economic growth and productivity. As is detailed in subsequent chapters of this report, the sector is integral to the country's ability to innovate, attract investment, and develop infrastructure. Engineering is at the heart of technological advances in industrial digitalisation, automation and artificial intelligence and the delivery of major infrastructure projects such as Crossrail, High Speed 2, and fibre-optic broadband.

The economic contributions the engineering sector makes to the UK economy are accordingly considerable. Our analysis shows that in 2016, engineering enterprises employed 18.9% of the UK labour force and generated 23.2% of its £5.3 trillion turnover.[1.1] Altogether, the sector's estimated contribution, in terms of Gross Value Added (GVA), is larger than the retail and wholesale, and financial and insurance sectors combined, and 56% more productive (GVA/person) than the retail and wholesale sector.[1.2] And this already significant economic contribution is only expected to increase: by 2020, the engineering sector's direct contribution to the Gross Domestic Product (GDP) is projected to increase to £608Bn.

Beyond the vital role it plays in the UK economy, engineering is also fundamental to improving quality of life and bringing into being solutions to some of society's most pressing challenges. As elaborated in **Chapter 2**, engineering – far from being limited to the hard hat stereotype so often perceived – is a diverse discipline that touches every part of daily life, with applications in fields ranging from renewable energy, to cybersecurity, to biotechnology.

Critical to the continued economic and societal contributions of the engineering sector is the supply of skills and talent. While the engineering skills shortage has been a longstanding issue in the UK, technological advancements and an increasing fusion of the digital, physical, and biological are leading to new fields of engineering – and exacerbating already high demand for highly skilled labour. Chapter 10 provides a detailed analysis of demand projections for people with engineering skills going forwards. We estimate that between 2014 and 2024, there will be an annual demand for 124,000 engineers and technicians with core engineering skills across the economy. Alongside this, there will be an additional annual requirement for 79,000 "related" roles requiring a mixed application of engineering knowledge and skill alongside other skill sets.

As the UK moves further towards an hourglass economy, there are clear implications for the engineering sector and its skills needs. And as the engineering sector and its skills needs change, so too does the context in which it operates. With this in mind, this chapter discusses the broader context in which the UK engineering sector is situated, outlining the UK's longstanding issues of low productivity and skills shortages, and the potential challenges leaving the European Union may bring. It then discusses the key government policies and strategies currently in place to foster the right skills, investment and infrastructure to drive forward UK economic growth and productivity.

1.2 – The productivity puzzle

As detailed in **Chapter 7**, recent years have seen a substantial increase in the number of people employed and a decline in unemployment in the UK. In fact, in 2017 some 32 million people were employed in the UK in 2017, representing an employment rate of 74.9% – the highest rate since comparable records began in 1971.[1.3]

However, productivity – that is, how much is produced for a given input, such as an hour's work – has remained stubbornly low. According to the Office for Budget Responsibility (OBR), output per hour has risen only 0.2% since the 2008 financial crisis, compared to an average of 2.1% a year over the preceding 35 years.[1.4] As a key factor in a national economy's standard of living, low productivity has negative implications for the UK's economic growth and, correspondingly, prosperity and quality of life. Furthermore, this trend is expected to continue: in its forecast in November 2017, the OBR estimated that productivity growth will fall from 1.8% to 1% in 2020.[1.5]

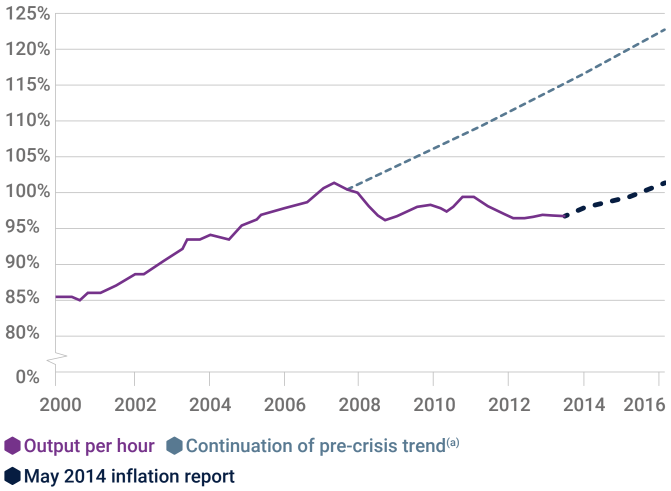
While 2015 is the latest year for which final estimates of international comparisons of UK productivity (ICP) are available from the ONS, these nevertheless provide a startling picture of the UK 'productivity puzzle' – that is, the difference between post-downturn productivity performance and the pre-downturn trend (**Figure 1.1**).[1.6] As **Figure 1.2** shows, although all G7 nations experienced a decline in productivity following the 2008 financial crisis, the UK has lagged behind many of them, in terms of productivity, since.[1.7]

The UK's gap in productivity since the 2008 financial crisis is the largest of the G7 countries.

In the ten years leading up the 2008 financial crisis, the UK's average annual productivity growth was 0.3 percentage points higher than the average across the G7 advanced economies. Comparing the UK's average productivity growth in this period to that of 2007 to 2015, the ONS found a gap of 15.2%.[1.8] In other words, output per hour in 2015 was 15.2% lower than under a counterfactual scenario where UK productivity continued to grow at its pre-downturn trend since 2007. This productivity gap was the largest in the G7 and twice the average gap of 7.5% across the rest of the G7. As of 2017, the UK is estimated to have the third lowest rate of productivity among the G7 countries, lagging behind the Germany, France, United States, and Italy.[1.9]

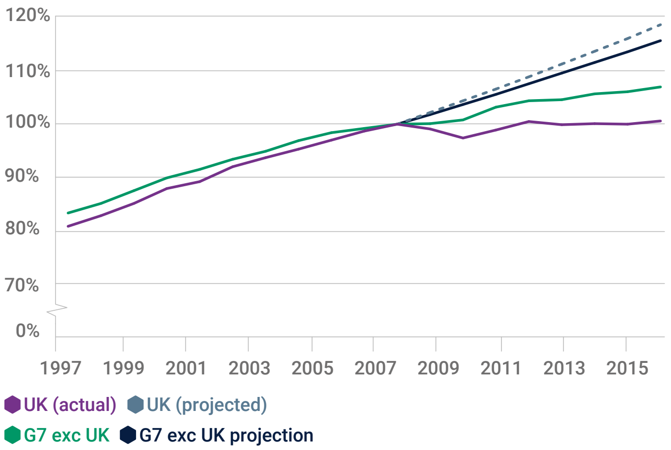
1.1 ONS. 'IDBR: analysis of the engineering industry by size and region 2009 to 2016', 2017.
1.2 Cebr. 'The contribution of engineering to the UK economy – the multiplier impacts', January 2015.
1.3 ONS. 'UK Labour Market Statistical Bulletin: July 2017', July 2017.
1.4 OBR. 'Economic and fiscal outlook', November 2017.
1.5 Ibid
1.6 Bank of England. 'The UK productivity Puzzle, Quarterly Bulletin 2014 Q2', 2014.
1.7 ONS. 'International comparisons of UK productivity (ICP), final estimates: 2015', April 2017.
1.8 Ibid
1.9 OECD. 'GDP per hour worked', 2017.

Figure 1.1 The productivity puzzle: productivity slowdown since the 2008 financial crisis – UK



Source: ONS and Bank of England calculations.
(a) Pre-crisis trend growth is calculation between 1997 and 2008 Q1, and is projected forward from 2008 Q1

Figure 1.2 Constant price GDP per hour worked (actual and projections) for the period 1997 to 2015 – UK and G7 countries



Source: OECD, Eurostat and ONS calculations

Because unemployment is at a record low, only limited economic growth can be achieved by simply recruiting more people. The productivity of existing employees needs to be improved, both through investment in technology and in skills.

The reasons for the UK's productivity slowdown in relation to that of comparator nations has been the source of much debate. This report has provided detailed analysis of the challenge in the past, noting that the underlying factors remain unclear. A number of sources suggest three factors are at work:[1.10,1.11,1.12]

The low level of investment in the UK compared with other industrialised economies. Business investment in new technology can help make workers more productive. Strikingly, data from the ONS indicates capital spending in the UK is only 5% above its peak prior to the 2008 financial crisis, compared with a 60% increase over the decade after the 1980s recession and 30% following the 1990s slowdown. The Financial Times suggests that this may be due to uncertainty about the future economic outlook.[1.13]

Low interest rates. Interest rates have been at a historic low for more than a decade, with an announcement to increase them from 0.25% to 0.5% in November 2017 representing the first rise since July 2007.[1.14] The BoE suggests that the low level of bank rate could have led to 'higher firm survival' – that is, fewer businesses failing and, as a consequence, a higher proportion of companies with below average productivity in operation.

Retention/hiring of lower-productive staff. Amid a general skills crisis across the economy it is thought that roles are often filled by lower productive staff. This is supported by sluggish real wages growth, which may be encouraging companies to hire staff over investing as a means of expanding their business, particularly in low-wage, low-skill sectors.

While there remains no consensus on the reasons behind the productivity puzzle, what is clear is that because unemployment is at a record low, only limited economic growth can be achieved by simply recruiting more people. The productivity of existing employees needs to be improved, both through investment in technology and in skills.

1.3 – Evolving skills needs

Key to addressing the productivity puzzle, then, is increasing skills among the labour force – but this has proven challenging within a wider context of skills shortages, and a growing trend toward a so-called hourglass economy (**Figure 1.3**).

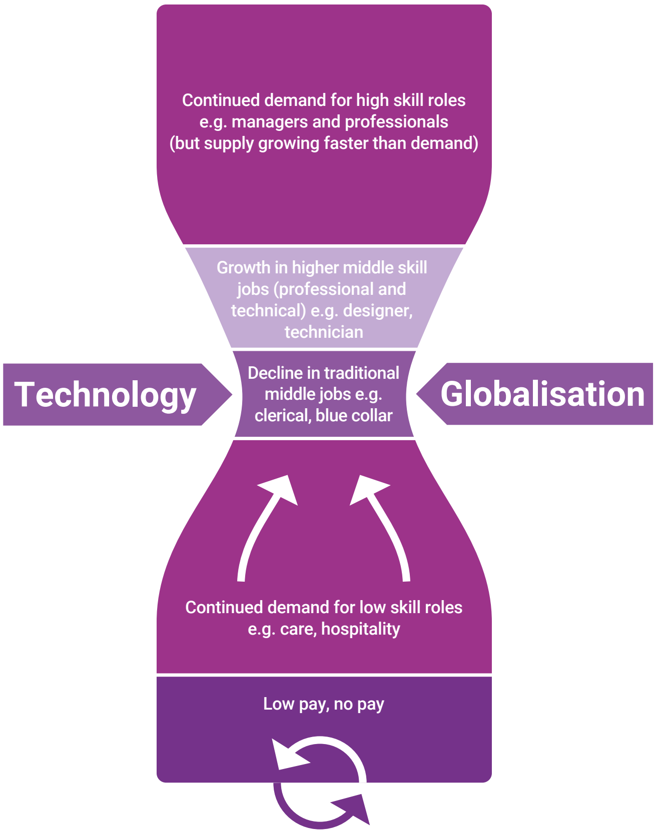
In the two decades to 2014, the number of high-skilled jobs in the UK has risen by 2.3 million and, in some industries, such as engineering, employers are routinely reporting that they are struggling to fill positions.[1.15] Conversely, these advancements are reducing the need for middle-skilled workers (**Figure 1.4**). Over the same 20 year period, there has been a significant decrease in the demand for middle-level skilled workers, with 1.2 million fewer jobs available for these largely 'routine' occupations. It is estimated that 35% of existing UK jobs are at high risk of replacement by technology in the next twenty years, particularly at medium-skill levels.[1.16]

1.10 CBI. 'The UK's productivity puzzle? What business really thinks', September 2015.
1.11 EEF. 'The UK's Productivity Puzzle - what's the deal', January 2018.
1.12 Financial Times. 'Four theories to explain the UK's productivity woes', October 2017.
1.13 Ibid
1.14 BBC News. 'UK interest rates rise for first time in 10 years', November 2017.
1.15 Policy Network. 'Owning the future, How Britain can make it in a fast-changing word – A new direction for a more inclusive economy', August 2014.
1.16 Deloitte. 'Agiletown: The relentless march of technology and London's response', 2014.

In tandem with this, there has been a rise in lower-skilled jobs. While the semi-routine nature of many middle-skilled occupations has made them especially vulnerable to automation, many occupations that are traditionally low-skilled rely on other types of skill not readily automated. Although this trend holds for many economically developed countries, it appears particularly to be the case for the UK. A report by CIPD, for example, notes that with the exception of Spain, UK has a higher proportion of low-skilled jobs than any other country in the OECD.

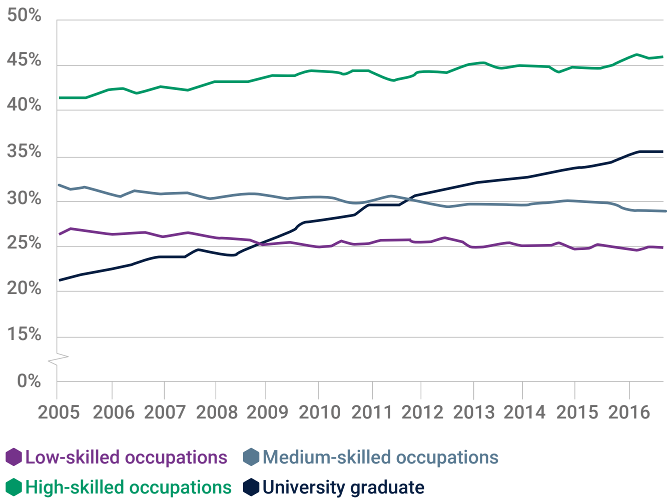
This 'hourglass' trend is expected to hold for the UK well into the future, with technological advances resulting in the expansion of knowledge-intensive services and ever increasing demand for highly skilled labour. As detailed in **Chapter 2**, a whole range of new industries are forecast to develop over the coming decades, impacting heavily on requirements for highly-skilled labour, and especially STEM skills.

Figure 1.3 The hourglass economy



Source: UKCES

Figure 1.4 Composition of the workforce from 2005 to 2016, by skill level of occupation and education [1.18]



Source: IFS, Labour Force Survey 2005-2016
Restricted to the 16–64 workforce. Adjusted for discontinuity caused by the introduction of SOC2010 occupation coding between 2010Q4 and 2011Q1. Skill level of occupation is defined by one-digit Standard Occupational Classification (SOC) 2000 code (SOC 2010 since 2011). 'High-skilled' is defined as codes 1– 3, 'medium-skilled' as codes 4–6 and 'low-skilled' as codes 7–9.

Employers and the skills gap

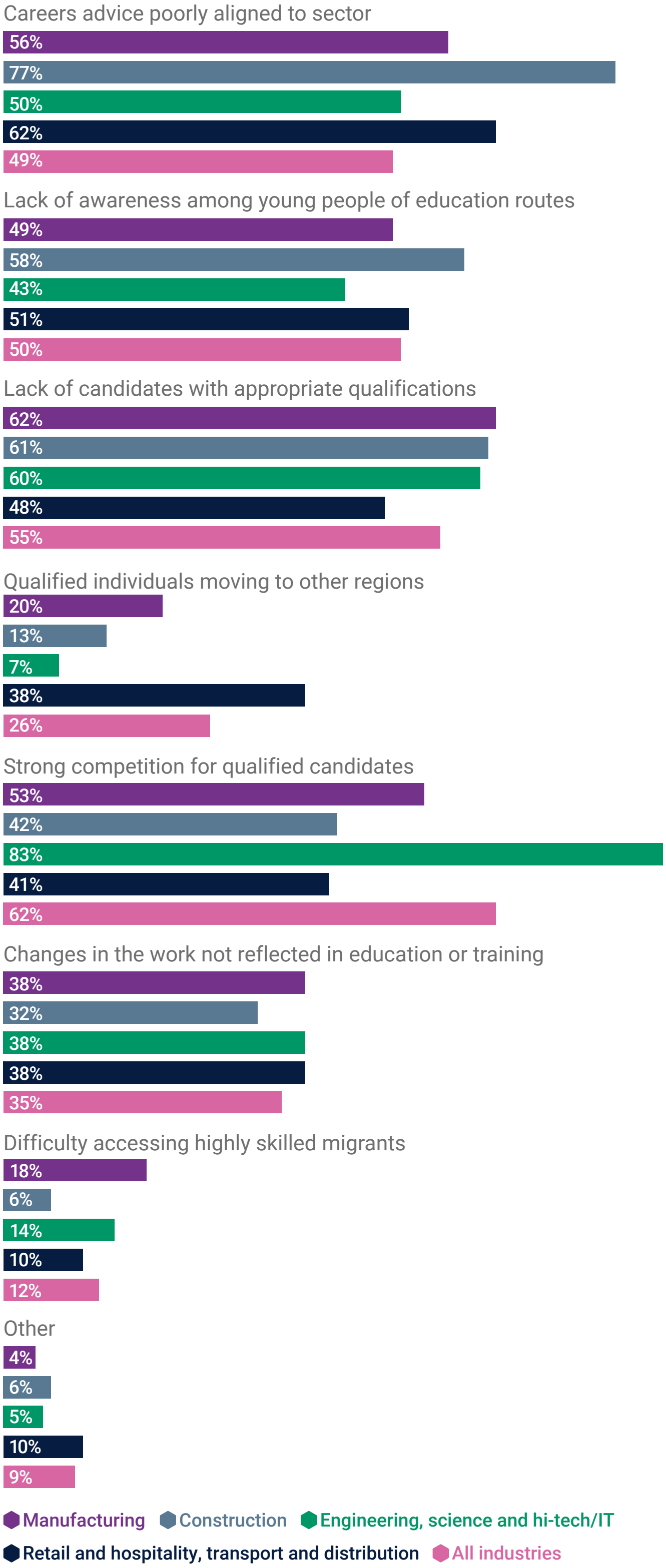
The increasing demand for high skilled roles is a concern for many employers. In 2017, three quarters of businesses surveyed in the CBI/Pearson Education and Skills Survey expected to have more job openings for people with higher level skills over the coming years, and 61% expressed a lack of confidence that there will be enough people available in the future with the necessary skills to fill their high-skilled job vacancies.[1.19]

Strong competition for candidates with appropriate qualifications (62%) and a lack of candidates with appropriate qualifications (55%) were identified as the most widespread cause of the skills gap, but ranking almost as high was lack of awareness among young people of education routes to enter particular careers (50%) and careers advice poorly aligned to the sector (49%). Notably, the proportion of employers reporting a lack of candidates with appropriate qualifications was much higher among the manufacturing, construction, and engineering, science and hi-tech/IT sectors than on average (**Figure 1.5**).

According to a CBI/Pearson survey, 61% of employers were not confident there would be enough people with the necessary skills to fill their high-skilled vacancies.

1.18 IFS. 'The UK labour market: where we stand now?', April 2017.
1.19 CBI/Pearson. 'Helping the UK thrive: Education and Skills Survey 2017', July 2017.

Figure 1.5 Main drivers of skills gaps reported by employers and sector



Source: CBI/Pearson Education and Skills Survey 2017

Similar findings were reported in the latest Skills and Demand in Industry Survey conducted by the Institution of Engineering and Technology (IET) in 2017.[1.20] Of those employers surveyed, 46% reported they had experienced recruitment difficulties due a lack of suitably skilled candidates, and a quarter noted skills gaps or limitations in their existing workforces. The majority moreover anticipated this would be a key difficulty going forwards, with three in five ranking the recruitment of people with the right engineering skills as the top challenge in achieving their business objectives in the next three years (61%). Of those reporting a lack of skills in the labour market, 70% expressed a concern in the supply or quality of young people entering or seeking to enter the engineering industry.

This resonates with the findings of the last employer skill survey conducted by the now defunct UK Commission for Employment and Skills (UKCES) in 2015.[1.21] Between 2013 and 2015, there was a 43% rise in the number of skill-shortage vacancies reported, with nearly 20% of employers indicating that they had at least one current vacancy.[1.22] Commonly cited reasons for these skill-shortage vacancies included a lack of candidates with the requisite technical and practical skills, such as specialist knowledge, the ability to solve complex problems and IT knowledge.

Notably, a lack of people and personal skills was also reported to drive skill-shortage vacancies. Over half of employers surveyed by UKCES reported the ability to manage one's own time and prioritise tasks (59%) and team working (56%) as skills lacking among staff with skills gaps. These findings correspond with those of the Wakeham and Shadbolt Reviews, both of which noted a lack of 'soft skills' among STEM and computer science graduates, and our own analysis of graduate destinations in **Chapter 8**.[1.23,1.24] While there are clear skills shortages in engineering and computing, unemployment rates for recent graduates in these subjects are higher than for other subjects. A lack of employability skills could go some way to explaining this paradox.

The 2015 UKCES Employer Skills Survey is also illuminating in terms of the adverse impact skills shortage vacancies (SSVs) are expected to have on industry, particularly those engineering-related. As Figure 1.6 shows, 83.4% of respondents reported an increased workload for existing staff as a result of unfilled vacancies, and this was even more marked in engineering (87.0%). 56.1% of engineering employers surveyed also reported difficulties meeting customer needs. Crucially for a technology-based sector like engineering, there were also implications in terms of delays to new products or services, as well as the risk of losing business to competitors. A relatively common solution (for 27.5% of all enterprises and 35.2% of those engineering-related) was to outsource work, a response that could adversely impact on skill development and retention.

1.20 IET. '2017 IET skills survey', December 2017.
1.21 UKCES. 'Employer Skills Survey: UK Results. Evidence Report 97', May 2016.
1.22 Ibid
1.24 BIS. 'Wakeham Review of STEM Degree Provision and Graduate Employability', May 2016.
1.24 BIS. 'Computer science degree accreditation and graduate employability: Shadbolt review', May 2016.

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Figure 1.6 Most common implications of hard-to-fill vacancies on enterprises 2015

	All enterprises		All engineering enterprises	
	No.	%	No.	%
Increase workload for other staff	74,817	83.4%	16,153	87.0%
Have difficulties meeting customer services objectives	42,139	47.0%	10,414	56.1%
Delay developing new products or services	36,763	41.0%	8,963	48.3%
Lose business or orders to competitors	36,251	40.4%	8,421	45.4%
Experience increased operating costs	36,003	40.1%	8,309	44.8%
Have difficulties introducing new working practices	31,720	35.3%	5,712	30.8%
Have difficulties meeting quality standards	29,826	33.2%	5,578	30.1%
Outsource work	24,707	27.5%	6,538	35.2%
Withdraw from offering certain products or services altogether	20,860	23.2%	4,377	23.6%
Have difficulties introducing technological change	17,862	19.9%	4,789	25.8%

Source: UKCES, Employer Skills Survey 2015

1.4 – Uncertainty around leaving the European Union

In this context, the UK electorate's vote to leave the European Union in June 2016 has raised concerns about how it may exacerbate the already acute skills shortage in engineering.

The ramifications of the historic referendum verdict and subsequent invocation of article 50 in March 2017 will not become fully manifest for months or even years from now. What is, however, clear is that engineering must play a central part in the UK's international trade future. As this report shows, the engineering sector produces the majority of the nation's exports and is critical to the UK's international competitiveness, through its investment in research and innovation. The extent of the impact of leaving the EU on the engineering sector will depend on many factors, including the arrangements for movement of goods, services, labour and capital negotiated between the UK, the EU and the rest of the world.

A key concern is that the UK's exit from the European Union may have implications on the current status quo of free movement, which allows EU citizens to move, live and work freely in any EU member state. At present, this allows UK based engineering organisations to easily recruit from a European wide pool of engineering talent, an important tool in protecting against the existing engineering skills shortage. If access to the European engineering workforce becomes more restricted, it risks exacerbating this crisis.

Accurate figures are not available for the total number of non-UK EU nationals working as engineers in the UK, as there is currently no requirement for this information to be recorded. What is recorded is certain to not be complete. Figures on the number of engineers utilising the Mutual Recognition of Professional Qualifications Directive in the UK, for example, do not provide a complete picture as many engineering activities can be practised without the need to be registered as a professional engineer in the UK.

Existing employment statistics by industry nevertheless give an indication of the important contribution EU nationals make to the engineering workforce. Data from the Labour Force Survey shows that 7.7% of workers in the EngineeringUK sectoral footprint in 2016 were EU nationals, compared with 6.1% in non engineering sectors. In the first quarter of 2017, EU nationals made up a higher share of the workforce in key engineering-related industries such as manufacturing (11.5%), construction (8.7%) and professional, scientific and technical activities (8.1%) than in the labour force overall (7.3%).[1.25] There is furthermore some evidence that this may in fact be higher within engineering companies. Engineering companies have, for instance, reported employment proportions of between 10% to 20% for non-UK EU nationals and between 13% to 50% for non-EU nationals to the Royal Academy of Engineering.

There is a wealth of data that underscores the reliance of higher education on EU and non-EU nationals. The engineering pipeline is particularly vulnerable to changes that may result from the UK leaving the EU because a disproportionately high proportion of engineering and technology students are from overseas. This is particularly the case at postgraduate level, where in the academic year 2015 to 2016 14.6% of engineering and technology entrants were from the EU and a further 54.6% from a non-EU country.[1.26] Beyond its direct implications on the supply of graduates with engineering skills, Brexit also has the potential to affect the quality of UK HE teaching and research, via reductions in the outward mobility opportunities for academic staff, the ability to attract international talent and the UK's access to research and innovation funding and collaboration.[1.27]

While any change to the free movement of people in the EU would, in principle, only directly affect potential students from the EU, there are concerns that the UK's decision to leave the EU may also have an impact on potential staff and students' perceptions of the UK as an attractive place to study or work from further afield. As is detailed in **Chapter 6**, research into prospective students looking to study abroad suggest the referendum result has already negatively affected conceptions of the UK as a prestigious and desirable place to study.[1.28]

1.25 House of Commons Library. 'Mitigation statistics', January 2018.
1.26 HESA. 'Student record 2015/16', 2017.
1.27 UUK. 'What should be the government's priorities for exit negotiations and policy development to maximise the contribution of British universities to a successful and global UK?', June 2017.
1.28 QS Intelligence Unit. 'Is Brexit Turning International Students Away From the UK?', 2017.

There are concerns that the debate on immigration and the rhetoric around Brexit could adversely impact on the views of those international students and researchers considering the UK.

In recognition of these risks, the 2016 Engineering the Future report, *Engineering a Future outside of the EU,* recommended that the government and the engineering community:

- seize the opportunity to use the combination of leaving the EU and the commitment to a new industrial strategy to take decisive action on the UK's engineering skills crisis
- work with industry to identify the gaps in essential skilled engineering occupations that cannot be filled domestically in the short term and develop straightforward and cost-effective solutions [1.29]

The report noted that while other sectors would face many of the same challenges brought on by any changes to the free movement of people in the EU, some features are distinctive to or more pronounced in engineering. These included: the fact that across industries and skill levels, the engineering sector is comprised of a particularly mobile workforce; the tendency for engineering companies to recruit from a global talent pool, with UK engineers in high demand internationally; and the nature of engineering itself, as a team-based activity that is inherently collaborative and interdisciplinary.

Although the report highlighted the skills shortage as a key driver, it importantly underscored that the ability to share knowledge and people around the world is an essential characteristic of the fields in which engineers work. In this way, international mobility is, and will always remain, an essential feature of both the engineering sector and of the education sector on which the profession depends.

1.5 – Government strategies

In the context of this changing political and economic landscape, the engineering skills gap continues to have a high profile in across the UK governments, with significant investment in developing STEM skills and numerous policy initiatives aimed at increasing the take up of STEM subjects, the status of technical education and the supply of engineers.

There are a number of policy initiatives that seek to address, or are likely to impact, the engineering skills shortage, which span several different UK government departments. There are also changes in Whitehall that reflect the priority the issue is being given, including a newly appointed STEM lead in the Department for Education designed to improve co-ordination and the development of STEM governance boards across departments.

A map of the departmental responsibilities for STEM skills can be found in **Figure 1.7**.

Figure 1.7 Main departmental responsibilities for STEM

Responsibility for funding, managing and delivering STEM skills is spread across a number of departments.

Department for Education

- Schools
- Further education
- Higher education
- Apprenticeships
- Lifelong learning
- Careers in strategy
- Labour market intelligence

Department for Business, Energy & Industrial strategy

- Managing industrial strategy overall
- STEM outreach (e.g. STEM inspiration)
- Significant role in R&D policies and funding
- Labour market intelligence

Department for Digital, Culture, Media & Sport

- Digital skills
- Cyber security
- Digital strategy

Department for Transport

- Transport infrastructure skills strategy
- STEM apprenticeships programme

Ministry of Defence

- Defence STEM engagement programme
- STEM apprenticeships programme

Other departments

- HM Treasury
- Cabinet Office
- Home Office

Source: NAO, 2018

1.29 RaEng. 'Engineering a future outside the EU', 2016.

In their January 2018 audit of government STEM skills activity, the National Audit Office (NAO) found that government efforts to address the STEM skills gap are hampered by the lack of a consistent definition of STEM skills and a comprehensive understanding of the issues.[1.30]

It furthermore flagged the closure of the United Kingdom Commission for Employment and Skills (UKCES) as a threat to the proper understanding of the STEM skills supply and raised concerns over the potential of local skills assessment panels to fill this gap. This is a clear concern for EngineeringUK, as it is UKCES' *Working Futures* that forms the basis for our own demand forecasts. As a result of UKCES closing in March 2017, it is uncertain whether further updates of *Working Futures* will take place, which has significant bearing on our ability to estimate demand for engineering skills in the future.

Many of the policy developments happening across Westminster are designed to integrate with the objectives of the recently launched government industrial strategy. Though managed by the Department for Business, Energy and Industrial Strategy, this is an effort to provide strategic direction to government intervention across departments.

Industrial Strategy

The industrial strategy white paper, *Building a Britain fit for the future*, was published in November 2017 and was welcomed by the engineering sector.[1.31] The strategy sets out five 'foundations' of growth: ideas, people, infrastructure, business environment and places – with local industrial strategies to be developed. It also puts forth 'grand challenges' designed to ensure the UK is properly positioned to shape and lead the industries of the future:

- put the UK at the forefront of the artificial intelligence and the data revolution
- maximise the advantages for UK industry from the global shift to clean growth
- become a world leader in shaping the future of mobility
- harness the power of innovation to help meet the needs of an ageing society

Importantly, the industrial strategy white paper emphasises the important role of education in driving skills, economic growth and productivity. It highlights the need to identify and address sector-specific skills gaps, and noted in particular shortfalls in STEM skills and its relationship to productivity.

The industrial strategy white paper highlighted the need to identify and address sector-specific skills gaps, noting in particular shortfalls in STEM skills and its relationship to productivity.

To achieve this, the strategy sets out a number of policies requiring concerted action from the Department of Education (DfE), the Department for Business, Energy and Industrial Strategy (BEIS) and other departments with a significant stake in skills and education policy, such as the Department for Transport (DfT) and the Ministry of Housing, Communities and Local Government (MHCLG, formerly the Department for Communities and Local Government). These include efforts to:

- improve basic skills and support re-skilling (e.g. through an £64 million investment in a National Retraining Scheme focusing on digital and construction skills)
- boost learning in maths, digital and technical skills through a £406m investment
- support social mobility by expanding equality of opportunity in the education system
- improve the quality of careers information and guidance in schools
- create a new system of technical education to match the UK's world-class higher education system
- deliver the regulatory reforms set out in the Higher Education and Research Act (HERA) 2017 so that higher education is responsive to employer and industry needs
- consider how government investment programmes can be designed to support industrial strategy objectives - including on skills development in key sectors – through initiatives such as the DfT's Transport Infrastructure Skills Strategy; and
- push devolution further to support improved business environments and productivity levels across all areas of the UK

Policy developments in social mobility, technical education and careers guidance are discussed in more detail in the section below, followed by more detailed discussions of HERA 2017 (BEIS), the Transport infrastructure skills strategy (DfT) and devolution and metro mayors (MHCLG).

The industrial strategy also launched sector deals – partnerships between government and industry aiming to increase sector productivity. Notably, the first of these announced in November 2017 all fall in the engineering footprint: life sciences, construction, artificial intelligence and the automotive sector. An independent industrial strategy council will be created to assess progress and make recommendations to the government.

While welcoming the industrial strategy, manufacturer's organisation EEF emphasised the need to monitor its implementation. Concerned by the lack of detail on the industrial strategy council in the White Paper, EEF made recommendations for how the body should operate.[1.32] More detail is likely to emerge over the coming months and will be an area of significant interest and monitoring.

1.30 NAO. 'Delivering STEM-Science, technology, engineering and-mathematics skills for the economy', January 2018.
1.31 RaEng. 'Academy responds to government industrial strategy white paper', November 2017.
1.32 EEF. 'What manufacturers make of plans for an Industrial Strategy Council', January 2018.

Industrial Strategy

Five foundations of productivity

1. Ideas: to be the world's most innovative economy

This includes a target to raise total research and development investment to 2.4% of GDP by 2027, as well as a £725 million new industrial strategy challenge fund.

2. People: to generate good jobs and greater earning power for all

Referring to skills training, this includes technical education policy reforms, alongside £406 additional funding for maths, digital and technical education.

3. Infrastructure: a major upgrade to the UK's infrastructure

The National Productivity Investment Fund will be increased to £31 billion for investments in transport, housing and digital infrastructure. There will also be £400 million towards electric vehicle charging infrastructure and over £1 billion for digital infrastructure.

4. Business environment: to be the best place to start and grow a business

This includes 'sector deal' partnerships between government and industry. There will also be a review into improving the productivity of small medium enterprises (SMEs). A £2.5 billion investment fund will provide the capital for high-growth innovative businesses to scale up.

5. Places: to have prosperous communities across the UK

Local industrial strategies are intended to be a key part of driving forward prosperous communities across the UK. These will identify priorities to improve skills, increase innovation, and enhance infrastructure and business growth. The first of these is to be agreed March 2019. They will be led by local enterprise partnerships (LEPS) and mayors. There is also a £1.7 billion 'Transforming Cities' fund to improve connections within city regions.

Four grand challenges

1. Growing the artificial intelligence (AI) and data driven economy

The strategy sees artificial intelligence and data as key to driving economic growth. To accelerate AI take up by industry, the government will create an industry-led AI council supported by a government office for AI. The Office for AI will focus initially on six sectors: cyber security, life sciences, construction, manufacturing, energy, and agricultural technology.

2. Maximising the advantages for UK industry from the global shift to clean growth

The strategy notes that the global shift to clean growth offers significant opportunity for the UK to become a world leader in the development, manufacture and use of low carbon technologies, systems and services. Its current strengths include electric vehicle manufacture, smart energy systems, offshore wind, construction and green finance.

3. Being a world leader in shaping the future of mobility

It furthermore highlights the need to improve the UK road and rail network to reduce pollution and congestion, and to further develop autonomous aerial and marine transport. This will also include new business models such as ride sharing.

4. Harnessing the power of innovation to help meet the needs of an ageing society

Finally, the strategy underscores the UK's increasing trend toward an ageing population, and the effect that will have on demand for new car technologies, housing models and savings products for retirement. Efforts outlined include working with organisations to adapt their workplaces to an ageing workforce, and developing NHS datasets to diagnose and treat health conditions earlier.

Social Mobility Action Plan

Social mobility has been a significant cross-cutting area of focus for the DfE under Justine Greening, who held the position of Secretary of State for Education until January 2018. This culminated in the publication of *Unlocking Talent, Fulfilling Potential* in December 2017. First announced in the industrial strategy white paper, this is the government's action plan for improving social mobility in England.

Four ambitions of the Social Mobility Action Plan[1.33]

Ambition 1: Closing the word gap

Boosting access to high quality early language and literacy, both in the classroom and at home, ensuring more disadvantaged children leave school having mastered the basic of literacy that many take for granted.

- ensuring more disadvantage children are able to experience a language rich early environment
- improving the availability and take-up of high quality early years provision by disadvantaged children and in challenging areas
- improving the quality of early years provision in challenging areas by spreading best practice

Ambition 2: Closing the attainment gap

Raising standards for every pupil, supporting teachers early in their career as well as getting more great teachers in areas where there remain significant challenges.

- improving the quality of teaching in challenge in areas and schools
- improving the school improvement offer in more challenging areas
- supporting pupils from less advantaged backgrounds of all abilities to fulfil their potential

Ambition 3: Real choice at post-16

Creating world-class technical education, backed by a half a billion pounds in investment, and increasing the options for all young people regardless of their background.

- creating high quality technical education options to improve the choice for young people at age 16
- investing in the further education sector
- ensuring young people from disadvantage background access the highest quality provision

Ambition 4: Rewarding careers for all

Boosting skills and confidence to make the leap from education into work, raising their career aspirations. Building a new type of partnership with businesses to improve advice, information and experiences for young people.

- collaborating with businesses large and small to widen opportunity, and drive up local skills and productivity
- improving the quality and availability of good careers guidance and experiences, targeting 'career cold spots'
- ensuring those in lower paid work are able to re-train to move into more rewarding careers

Providing high quality technical education options is seen as a way to address skills shortages and improve social mobility.

Of particular importance to the supply of engineers is ambition 3 of the action plan, which outlines the aim to provide high quality post-16 education choices for all young people, and ambition 4, which discusses the determination for people to achieve their potential in rewarding careers.

In ambition 3, the DfE recognises the added imperative driving the investment in skills from the uncertainty surrounding Brexit. It summarises progress made in reforming technical education, investing to support further education colleges to be centres of excellence in English and maths, the introduction of the apprenticeships levy and degree apprenticeships. It also recognises that a "skills revolution" is needed to meet the skills demands of employers effectively, especially in those areas left behind by economic change.[1.34]

Providing high quality technical education options is positioned as a way to both address skills shortages and increased social mobility. Improving the quality of technical education disproportionately benefits young people from disadvantaged backgrounds: only 36% of young people from disadvantaged backgrounds take A levels compared to 61% of those from more affluent backgrounds.[1.35] Involving employers in setting standards for both apprenticeships and technical qualifications is seen by the DfE as key to ensuring that young people who pursue technical routes are employable upon their completion.

Challenge Two of the action plan focuses on investing in the further education sector. The proposed mechanisms for this are:

- an extra £20 million to help colleges and teachers prepare for the introduction of T levels
- funding a strategic leadership programme for FE principals and establishing national leaders of further education to support colleagues
- establishing new institutes of technology, supported by a £170 million fund and expected to open from 2019, to act as a beacon of quality provision across all regions of England
- investing £40 million in the centres of excellence programme for the further education sector to help those who have fallen behind in English and Maths
- introducing a new transition year, with English and maths as a key component, for 16- year-olds who are not ready for more advanced academic or technical study or employment

1.33 DfE and the Rt Hon Justine Greening MP. 'Plan to boost social mobility through education', December 2017.
1.34 DfE. 'Unlocking Talent, Fulfilling Potential', December 2017.
1.35 Ibid

Only 36% of young people from disadvantaged backgrounds take A levels compared to 61% of those from more affluent backgrounds.

To complete the "skills revolution", the Social Mobility Action Plan also has a focus on widening participation to higher education. This includes an expectation of "far greater transparency by universities on what they expect from their applicants, especially those from disadvantaged backgrounds so they are aware of the subject choices, experiences and qualifications required to pursue different career options."[1.36] These efforts will be facilitated by the new transparency duty in the Higher Education and Research Act.

Careers Strategy

In December 2017 the Department for Education (DfE) published its long awaited careers strategy, *Careers strategy: making the most of everyone's skills and talents.* As highlighted by the industrial strategy white paper, the document sets out plans to improve the quality and coverage of careers advice for people of all ages. The strategy has four main strands:

- inspiring encounters with further and higher education, and with employers and workplaces, in order to provide young people first-hand experience of the workplace
- enhancing the advice and guidance schools and colleges deliver, such that they meet the Gatsby benchmarks[1.37]
- providing support and guidance tailored to individual needs, including personal guidance to help people make choices, supporting graduates into skilled employment, and targeted approaches for those who need it the most
- using data and technology to help people make informed choices about careers

The eight Gatsby benchmarks of good career guidance

1. A stable careers programme

2. Learning from career and labour market information

3. Addressing the needs of each pupil

4. Linking curriculum learning to careers

5. Encounters with employers and employees

6. Experiences of workplaces

7. Encounters with further and higher education

8. Personal guidance

More detail on these benchmarks can be found in **Figure 3.18** in **Chapter 3**.

The strategy was broadly well received, in particular the emphasis on ensuring that young people have multiple opportunities to interact with employers and the world of work. The provision of a clear timetable for action in the strategy was also welcomed, as it will allow the sector to hold government to account for progress.

There were, however, a number of concerns expressed. The Education Policy Institute cautioned that the requirement for schools to publish their own careers strategies with local-led solutions may encourage fragmentation and variability in careers provision, with worse positioned providers opting for low-cost alternatives.[1.38] However, it noted that the provision for Ofsted to inspect schools careers strategies could mitigate against this risk and overall concluded that the careers strategy was "welcome and necessary".

The adoption of the Gatsby benchmarks was also widely celebrated, though the Institution of Mechanical Engineers (IMechE) had some particular concerns about how this would work in practice:

"We support the adoption of Sir John Holman's Gatsby Good Career Guidance Benchmarks, but have real concerns that the original PwC costings (£207 million in the first year and £173 million per year thereafter) will not be met – and that we will end up with a new bureaucracy and little cultural change."[1.39]

The IMechE had additional concerns that the careers strategy does not adequately address the barriers in schools' provision of careers guidance, which it felt to be weighted against the provision of advice about technical education. It noted that simply allowing technical education providers access to pupils would not address issues of ingrained social prejudice against technical education and its lack of parity of esteem with academic learning.

Further, in its response to the careers strategy, the IMechE made clear that social mobility is of particular importance to developing future engineering skills: "Our research[1.40] shows that unless students come from an engineering heritage background, they are unlikely to know about it. We strongly believe that high quality career guidance is the engine of social mobility. The UK has a particular challenge in that 50% of an individual's lifetime earnings can be explained by their parents' earnings. It's 15% in Denmark." [1.41]

Technical education and apprenticeship reform since 2015

Delivering a world-class technical education system and driving up the quality and level of investment in apprenticeship provision are key tenets of the industrial strategy's people pillar. Nevertheless, the policies put forward to achieve this have been in the making for a number of years, starting with the reforms laid out in 2015 by the government's 2020 vision for apprenticeships in England. Technical education reforms were spelled out in 2016 by the DfE's Post-16 skills plan, which built on the challenges and solutions identified by the Sainsbury review. Some of the legal basis for these reforms is provided by the Technical and Further Education Act, which received royal assent in 2017. The Act also includes the so-called "Baker clause" (arising from an amendment proposed by former education secretary Lord Baker), which

1.36 Ibid
1.37 Gatsby Foundation. 'Good career guidance', 2014.
1.38 Education Policy Institute. 'Careers Strategy: Was it worth the Wait?', December 2017.
1.39 IMechE. 'Institution responds to the Careers strategy', December 2017.
1.40 IMechE. '"We think it's important, but don't quite know what it is": the culture of engineering in schools', November 2017.
1.41 IMechE. 'Institution responds to the Careers strategy', December 2017.

from January 2018 requires schools to give further education providers opportunities to inform pupils about the qualifications they offer, and publish a policy statement outlining how those providers can access their pupils. This a welcome intervention by the government to raise awareness of different forms of post-16 education in schools.

There are four main strands to the government's revised technical education landscape: T-Levels; review of higher technical education; driving increased apprenticeship provision; and take up and roll out of degree apprenticeships.

T levels: T levels are two-year, full-time level 3 study programmes, based on employer-designed standards and content. The first few courses will be available in 2020, according to the T-Level Action Plan, published in October 2017.[1.42] However, these will be restricted to just one pathway from each of the first three routes: digital, education and childcare and construction. The bulk of the pathways will not be offered by providers until 2024. The high-level timetable for implementation sees the engineering and manufacturing full route being implemented in 2021.

The Baker clause requires schools to give further education providers opportunities to inform pupils about the qualifications they offer.

Higher technical education: The government is conducting a review into how higher technical education at levels 4 and 5 can address the needs of individuals and employers and meet the skills needs of the economy. This was a crucial recommendation of the Sainsbury review and is seen as key to supporting social mobility both for young people and for adults upskilling or retraining. As this report highlights, there is an acute need for high level skills in the engineering sector, with an estimated shortfall of at least 22,000 graduates in core engineering roles per year through to 2024.

Apprenticeships: There have been substantial reforms to the apprenticeships system, which are discussed in detail in **Chapter 5**. A target to increase the number of apprenticeships starts has been a significant policy driver. To support the increase in provision, the government has implemented a levy on large employers to raise funds for the system and established an employer led Institute for Apprenticeships to provide quality assurance.

Degree Apprenticeships: Significant for the development of future engineering talent, degree apprenticeships offer level 6+ skills and include both academic excellence and significant on the job training. There is a specific commitment in the Social Mobility Action Plan to use part of the £10 million Degree Apprenticeship Development Fund to expand Degree Apprenticeship provision in science, technology, engineering and maths occupations (STEM) and gender diversity in STEM.

Higher Education and Research Act

The Higher Education and Research Act (HERA) received royal assent in April 2017 and is the first major regulatory change to Higher Education this century. This was not without contention: Lord Bilimoria claimed the Act may have been one of the most amended bills in the history of Parliament and there were several controversial issues during its passage through both houses.[1.43]

The Act is the legislative response to two policy papers: the Department for Business, Innovation and Skills 2016 white paper, *Success as a knowledge economy: teaching, social mobility and student choice* and Sir Paul Nurse's 2015 report, *Ensuring a successful UK research endeavour: a review of the UK research councils*. As suggested in the industrial strategy white paper, the Act aims to reform higher education to increase competition and choice in the sector, raise standards, and strengthen capabilities in UK research and innovation.[1.44]

Efforts to amend the Bill to remove international students from net migration figures were not successful.

For the engineering skills pipeline, it is significant that efforts to amend the Bill to remove international students from net migration figures were not successful. Despite such an amendment receiving a majority in the House of Lords, this was removed at a later stage in the House of Commons.[1.45] The House of Commons Education Committee warned that that the government's refusal to remove international students from the net immigration target is putting at risk the higher education sector's share of the international student market.[1.46] Our analysis of higher education in **Chapter 6**, which highlights the contributions international students make to universities and the engineering pipeline, supports this view.

There are concerns around proposals to link the TEF to increased tuition fees and overseas student recruitment, as well as the metrics it uses for employability.

The Act further enshrines the Teaching Excellence Framework (TEF). This has received a mixed response, with particular concerns raised over proposals to link the TEF to increased tuition fees and overseas student recruitment. There have furthermore been concerns raised about the metrics used to measure teaching quality and employability, the challenges of which are discussed in **Chapter 8**.

1.42 DfE. 'Post-16 technical education reforms: T-Level Action Plan', October 2017.
1.43 House of Lords Hansard. 'Higher Education and Research Bill' Volume 782, column 1480, April 2017.
1.44 House of Commons Library. 'Higher Education and Research Bill, Lords Amendments and Ping Pong'. Briefing papers CBP-7880, June 2017.
1.45 House of Commons Library. 'International and EU students in higher education in the UK FAQs. Commons Briefing papers CBP-7976', July 2017.
1.46 Ibid

The United Kingdom Research and Innovation (UKRI) body created by the Act will start operating from April 2018, under the leadership of Sir Mark Walport (as Chief Executive) and Sir John Kingman (as Chair). UKRI will bring together the seven UK research councils, which will retain their names and characteristics, with Innovate UK's focus on economic growth and Research England, a new body that will undertake research and knowledge exchange funding. UKRI will operate across the whole of the UK with a combined budget of more than £6 billion.[1.47]

The intention behind UKRI is to bring the constituent parts of research and innovation together to ensure the UK maintains its world leading position in this respect. As Sir John Kingman noted, UKRI will act as a central "strategic brain" to improve the dynamism, collaboration and commercialisation of UK research and innovation, and give it a stronger and more unified voice at the heart of government. In his first speech as Minister of State for Universities, Science, Research and Innovation in January 2018, Sam Gyimah highlighted how UKRI will also facilitate a more strategic, agile and interdisciplinary approach to funding research. Further, he explained that Research England's work with the other UK funding bodies and the Office for Students will "help UKRI in its consideration of the sustainability of the research base, a joined up skills and talent pipeline and an approach to innovation which captures the strengths of each of the devolved nations."[1.48]

It is widely viewed that UKRI will face significant challenges from day one. In addition to ensuring a successful transition to a radically reformed UK research and innovation landscape, it will need to establish effective partnership working with the Office for Students on areas of joint responsibility (such as postgraduate research and knowledge exchange policy). It will also need to ensure the UK science base can continue to attract research talent from Europe and participate in European research networks after the UK's departure from the EU.

Transport Infrastructure Skills Strategy

In 2016 the Department for Transport published the *Transport Infrastructure Skills Strategy: building sustainable skills, moving Britain ahead.* The strategy sets out a call to action to employers, to government, to professional organisations and to educational institutions to come together to effect a real change in the transport sector. It highlights the need to encourage people into transport careers, both through apprenticeships and other means, so that the sector can meet the challenges of new technology and deliver the government's ambitious infrastructure programme.[1.49] It is mentioned in the industrial strategy white paper as an example of how government investment programmes can be used in a way that advances other strategic economic objectives, including addressing skills shortages in key industries.

The strategy puts forth the following ambitions:

- at least 20% of new entrants to engineering and technical apprenticeships in the transport sector to be women by 2020 and to achieve parity with the working population at the latest by 2030
- support the government's target of a 20% increase in the number of BME candidates undertaking apprenticeships by 2020
- help transport employers to come together through the Strategic Transport Apprenticeship Taskforce (STAT) to address skills challenges in a co-ordinated and collaborative way. The group will cover road and rail initially
- deliver a compelling and inspiring communications campaign to make 2018 the year to celebrate engineering, and promoting engineering as a career of choice to young people

In July 2017, the Strategic Transport Apprenticeship Taskforce (STAT), which was established in April 2016, published a report on progress, entitled *Transport Infrastructure Skills Strategy: one year on.*[1.50] They noted that skills requirements were introduced into all relevant invitations to tender in April 2016, including in rail franchising, a move they anticipated would increase apprentice numbers. In addition, the report concluded that there has been some progress towards the strategy's ambition to improve gender diversity in the sector workforce, noting that 12% of women technical and engineering apprenticeship starts in the supply chain were women in 2016. However, it recognised there is much more to do to reach that ambition.[1.51]

Between the development of the initial strategy and the publication of the taskforce report, the key Brexit vote occurred. The Taskforce report made clear that this will impact upon the skills modelling that had been undertaken. Their initial figures showed that the UK rail industry has a significant population of non-UK EU workers:

"Highways England initial estimates also suggest that over 20% of their workforce are of non-UK EU origin. There is significant reliance on non-UK EU workers in specific rail disciplines (for example in electrical engineering), among service staff working for train operators, and particularly in infrastructure construction. Research projects conducted by NSAR and corroborated by CITB6 also suggests that non-UK EU workers may comprise up to half of the workforce at skill level 2 in London and the South East. Our planning going forward will need to take account of these dimensions." [1.52]

1.47 BIS and Jo Johnson MP. 'John Kingman to lead creation of new £6 billion research and innovation body', May 2016.
1.48 BEIS, UKRI, and Sam Gyimah MP. 'UKRI Research and Innovation Infrastructure Roadmap launch', January 2018.
1.49 DfE. 'Transport Infrastructure Skills Strategy: building sustainable skills', 2016.
1.50 DfE. 'Transport Infrastructure Skills Strategy: one year on, a report by the Strategic Transport Apprenticeship Taskforce', July 2017.
1.51 Ibid
1.52 Ibid

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The STAT report furthermore identified a concern that a focus on higher level apprenticeships may have a negative impact on social mobility. It highlighted an ambition to "amplify the ability for an apprentice to start work at a junior level and to finish their career in the boardroom." [1.53] An area of future action for the group is to develop the use of pre-apprenticeship programmes, traineeships and work experience to enable people to progress to higher level apprenticeships.

The Year of Engineering 2018, a cross-government campaign to showcase careers in the profession, was launched on 15th January 2018, fulfilling a commitment in the Transport Skills Strategy.

The Year of Engineering

The Year of Engineering 2018 was launched on 15th January 2018, fulfilling a commitment in the Transport Skills Strategy made by Rt Hon Sir Patrick McLoughlin as Secretary of State for Transport. The Year of Engineering is a cross-government campaign that aims to showcase engineering careers throughout 2018 through a series of initiatives, resources and events. Partners from across the engineering sector have joined with government to promote the Year of Engineering, which aims to aims to provide at least one million engineering experiences, including school trips and the opportunity to meet industry professionals, to young people. [1.54] There is a focus amongst the partners in ensuring that the legacy of the Year of Engineering stretches beyond 2018.

Devolution and metro mayors

In announcing the introduction of Local Industrial Strategies by March 2019, the industrial strategy made it clear that the government sees increased local decision making (through City Deals, Growth Deals, Devolution Deals and Mayoral Combined Authorities) as instrumental to addressing disparities in economic performance, skills and infrastructure across the country.

The Cities and Local Government Devolution Act received Royal Asset in January 2016. The Act allowed for the devolution deals already agreed to be delivered, making provision for the election of metro mayors, who chair combined authorities made up of several local authorities. In May 2017, metro mayors were elected in Cambridgeshire and Peterborough, Greater Manchester, Liverpool City Region, Tees Valley, West Midlands and the West of England for the first time. In May 2018, the Sheffield city region will hold a vote for their Mayor.

The Adult Education Budget is to be devolved to all six mayoral combined authorities, and to the Mayor of London (via separate negotiations). It does not include funding for apprenticeships. Full devolution of funding was to take place from 2018-19. This has subsequently been delayed for a year to 2019-20, as the government has not yet laid the required Orders before Parliament. As part of the process, a local skills and employment strategy must be produced by the city-region. Though this devolution has been welcomed, a report by IPPR North, *Skills for the North: devolving technical education to cities*, noted that there is limited scope for the Adult Education Budget to be used for locally agreed priorities because the "vast majority of this budget must be spent on nationally-defined legal entitlements."[1.55]

Metro mayors have been vocal in their belief that skills policy is an area that would benefit from further devolution.

The powers of the metro mayors vary according to the individual deals each city-region has reached with the government, but centre around a responsibility for setting out a strategy to grow the city-region economy, with the majority having increased duties around skills development.[1.56] Metro mayors have been vocal in their belief that skills policy is an area that would benefit from further devolution. Following a summit of the six metro-mayors and the Mayor of London on 1 November 2017, the mayors issued a joint statement calling for a major and sustained programme of devolution to cities and regions including action to devolve control over skills, training and apprenticeship services.[1.57]

There have been other, more detailed calls for further skills devolution, such as a call from the Mayor of London for the unspent apprenticeship levy funds generated in the capital to go to the London government. This would be the first step towards London government taking full responsibility over apprenticeships policy like the devolved administrations in Scotland and Wales.

A second devolution deal was agreed with the West Midlands Combined Authority in November 2017. This deal includes £5 million for a construction skills training scheme and £250 million from the Transforming Cities fund to be spent on local intra-city transport priorities.[1.58]

In January 2018, the metro mayors joined together to author a letter to the Financial Times, urging government to rethink its policies on international students. They called for Britain to project a "more open and welcoming message" to overseas students, a move the Financial Times noted as "rare for a politically diverse group of mayors to act in concert on such a contentious political issue."[1.59] It remains to be seen what impact this joint action will have.

1.53 Ibid
1.54 DfE, DfT, the Rt Hon Chris Grayling MP, and the Rt Hon Anne Milton MP. 'Engineering in the spotlight for 2018 as government launches campaign to inspire the next generation', January 2018.
1.55 IPPR North. 'Skills for the North: devolving technical education to cities', January 2018.
1.56 Centre for Cities. 'Everything you need to know about metro mayors: an FAQ', June 2016.
1.57 House of Commons Library. 'Skills devolution in England', January 2018.
1.58 HM Treasury, the Rt Hon Philip Hammond MP, and Andrew Jones MP. 'A second devolution deal for the West Midlands', November 2017.
1.59 Financial Times. 'Metro mayors urge rethink on overseas student immigration policy', January 2018.

1.6 – Devolved administrations

In the devolved administrations, STEM education in schools was the focus of a number of flagship government initiatives in 2017.

Welsh Assembly Government

In July 2017, Welsh Education Secretary Kirsty Williams announced a £3.2 million drive to improve how maths is taught in Welsh schools. The 'network for excellence' will include advice and resources and staff development opportunities, as part of an effort to improve classroom practice in STEM subjects ahead of the rollout of the new school curriculum in 2020.[1.60] This is being developed by a network of 'pioneer schools' and entails revised A level courses and a restructuring of the 3-16 curriculum from subjects to six areas of learning experience, including one in science and technology and another in mathematics and numeracy.[1.61] Further, the Welsh Assembly launched a £1.3 million programme to set up 300 clubs to teach computer coding to 3 to 16 year olds.

Following an independent report on the underrepresentation of Women in STEM in 2016, last summer the Welsh government also set up a ministerially-chaired 'Women in STEM' board to oversee the implementation of the report's recommendations. These include monitoring the relative progression of girls in STEM beyond GCSE level and ensuring primary school teachers without a STEM background are given better awareness of key foundational concepts and issues in STEM.[1.63]

In Wales, a ministerially-chaired 'Women in STEM' board will monitor the progression of girls in STEM beyond GCSE level.

Scottish Government

Scotland saw the launch of a five year STEM education and training strategy in October 2017. This outlines the actions the Scottish government will take over the next five years in order to: deliver excellent STEM learning; ensure this is connected with the skills needs of employers; close the equity gap in STEM education participation and attainment; and inspire children, young people and adults to study STEM.

One key area of intervention for the strategy is STEM teaching in schools. Scotland has suffered significant recruitment and retention issues in recent years, which will be tackled by increasing recruitment from industry and enhanced professional learning packages for STEM teachers. Other measures include prioritising STEM in the expansion of modern apprenticeships and the development of graduate level and foundation apprenticeships; a new network of specialist STEM advisers for schools; dedicated support for digital skills development and tackling gender bias and stereotyping in STEM; a new Young STEM Leaders peer mentoring programme; and an online directory of STEM inspiration activities.[1.64]

In October 2017, the Scottish government launched a five year STEM education and training strategy, with recruitment and retention of STEM teachers a key priority.

Northern Ireland Assembly

In Northern Ireland, there were no major changes affecting the awarding of Council for the Curriculum, Examinations and Assessment (CCEA) A levels or GCSEs this summer. However, the first awards for CCEA revised AS levels were made in summer 2017, as were the first A level awards for non-CCEA courses started in September 2015.[1.65] CCEA has also launched a new GCSE in statistics, available for first teaching in September 2017.[1.66]

Higher education policy in the devolved nations

2017 also saw significant changes and challenges in higher education policy across the devolved nations. In Wales, the Diamond and Hazelkorn reviews will change the funding of higher education for institutions and students, as well as reorganise many key agencies. In Scotland, fair access remains a key concern despite the absence of fees, with a new fair access commissioner placing significant pressure on institutions and foreshadowing changes to university outcome agreements. And in Northern Ireland, budget cuts have hit universities hard. These present both opportunities and threats to equality and diversity outcomes.

1.60 Welsh Government. 'Drive to improve maths in schools launched', July 2017.
1.61 Welsh Government. 'New school curriculum', September 2017.
1.62 Welsh Government. 'New drive to connect Welsh pupils with coding', June 2017.
1.63 Welsh Government. 'Talented Women for a Successful Wales: a report on the education; recruitment; retention and promotion of women in STEM-related study and careers', March 2016.
1.64 Scottish Government. 'Science Technology Engineering Mathematics: Education and Training Strategy for Scotland', October 2017.
1.65 CCEA. 'Summer 2017 exams - CCEA Regulator writes to schools', June 2017.
1.66 CCEA. 'CCEA launches NEW GCSE Statistics qualification', June 2016.

2 - Engineering and its economic contributions

27% (687,575) of all UK enterprises were engineering-related in 2016

In 2017, the UK was the 8th largest manufacturing country by export in the world

Key points

Engineering footprint

Defining the total reach of engineering in the UK is no easy task. We rely on the engineering footprint to define which occupations and enterprises count as 'engineering' and to break the picture down further into 'core' engineering and engineering-related activities. The footprint, which has been revised since the Engineering UK 2017 report, also helps us analyse trends and developments within the sector.

Engineering enterprises

Just over a quarter (26.9% or 687,575) of the 2.55 million (2,554,510) registered enterprises in the UK fell within the engineering footprint in 2016. This increased by 5.6% between 2015 and 2016. The increase was across the UK and was highest in London, at 10.2%.

The largest proportion of enterprises within the footprint were in information and communications (29.2%), followed by construction (26.3%). 90.6% of engineering enterprises were micro sized (0-9 employees). These engineering micro enterprises were concentrated in construction, repairs of motor vehicles, information and communication and professional, scientific and technical activities.

Productivity

The 'productivity puzzle' – high employment coupled with low productivity – remains unchanged and unsolved. Engineering still has the potential to raise national productivity levels. The engineering sector has a strong multiplier effect on the economy, generating a further £1.45 GVA for every £1 GVA created directly in the engineering sectors. What's more, every additional person employed through engineering activity is estimated to create a further 1.74 jobs down the supply chain.

In 2016, engineering enterprises generated 23.2% of the UK's total turnover of £5.3 trillion (£1.23 trillion). This is 0.7% less than in 2015. Even so, engineering enterprises still account for over a fifth of total UK enterprise turnover.

One of the government's approaches to increasing national productivity is to upgrade national infrastructure. UK national infrastructure projects represent a significant proportion of construction activity.

Trends and emerging industries

Automation and connectivity are increasing across the engineering sector, although they have not yet reached a level that could be classed as 'industry 4.0'. New industries and technologies are also emerging:

- the UK medical technology market is the third largest in Europe: comprising 3,700 enterprises and employs 115,000 employees, it is worth £7.6 billion
- land-based engineering (covering machinery from tractors to hedge trimmers) employs 22,850 people in the UK and is worth £4 billion a year
- the UK automotive industry turned over £77.5 billion in 2017 and offered 83 different models of alternatively fuelled cars and vans
- in 2017, the UK became the world's second largest defence exporter. About 30,000 defence sector jobs were in research, design and engineering
- in construction, activity marginally increased in 2017 and major infrastructure projects offset declines elsewhere
- Network Rail's railway upgrade plan, which is due to complete in 2019, is the largest modernisation programme since the Victorian era
- UK off shore oil and gas has been declining but still employed 28,300 in 2017. Decommissioning of power plants increased in 2016, reaching 7% of total industry spend at £1.2 billion
- in 2017, renewables (not including nuclear power) provided the majority of the UK's electricity supply for the first time. The renewables sector employed nearly 126,000 people in 2016
- in manufacturing, the realisation of industry 4.0 is still some way off, but the connected factory is becoming more widespread
- the European cyber security market is forecast to be worth $25.3 billion in 2018

However, this largely positive news must be balanced with the huge uncertainty that the result to leave the EU poses for all the engineering sectors.

2.1 – Context

We explain in this chapter how we define engineering and how we use that definition across the engineering footprint. We then show the total contribution engineering makes to the UK economy. This is through revisiting the contribution engineering makes to UK productivity and through engineering enterprise turnover. Having revised the engineering footprint, it is worth noting that equivalent numbers given in previous Engineering UK reports are not directly comparable. Time series data from 2009, revised to reflect the new footprint, is available in our Excel resource.

We then give an overview of the engineering sectors to show the breadth of engineering activity. We include examples of engineering developments and emerging sectors, such as synthetic biology. We also consider enterprise turnover and contributions to the economy.

Engineering also contributes to the national economy indirectly: any upgrades made to national infrastructure will improve productivity by saving time and creating opportunities for economic growth. Such developments can also mitigate against potential economic losses. In light of this, we highlight a number of major infrastructure projects at various stages of development across the UK, and provide information about their estimated economic benefits.

Because engineering industries are so interwoven, some of the categories in the footprint inevitably overlap and developments or products in one may also be found in another. For this reason, we have had to make some arbitrary decisions on where the boundaries fall. In describing the sector, we have included the size of companies by the number of employees. A more detailed description of the engineering workforce is given in **Chapter 7**.

Common themes run through this chapter. One such theme is the increase in digitisation and use of technology. Another is skills shortages – largely because we are focusing on growing sectors. The most pervasive theme, however, is the uncertainty from the UK's decision to leave the EU. While the devaluation of the pound has made exports more competitive, it also has made imports of materials, goods, services and people more expensive. The future movement of skilled labour into the UK and its attractiveness as a place to live and work is also less certain: it is, in the words of the Construction Industry Training Board, "... one of the most significant unknowns".[2.1] We give a comprehensive analysis of predicted skills supply and shortages in **Chapter 10**.

2.2 – Defining the engineering sector: the engineering footprint

The Oxford English dictionary defines engineering as:

"the branch of science and technology concerned with the design, building, and use of machines, and structures; a field of study or activity concerned with modification or development in a particular area: software engineering".[2.2]

However, there is no universally accepted operational definition of engineering. Large scale civil engineering projects (such as the Queensferry crossing, covered later in this chapter) or mechanical engineering products are easily recognised as engineering. There is less agreement on the boundaries of what is or isn't engineering. The engineering footprint attempts to create a workable definition of engineering by classifying which jobs and industries count as 'engineering' using the Office for National Statistics (ONS) lists of jobs (standard occupational classification – SOC2010) and industries (standard industrial classification – SIC2007).[2.3] We use the resulting footprint as the basis for indicating the sector's contribution to the UK economy, its wider impacts, the needs for and supply of skills.

In the ONS SOC and SIC lists, jobs are grouped into classes by skill level and skill specialisation, while industries are grouped by activity. These codes go into several levels of detail. The engineering footprint is specified at the most detailed level for job (4 digit) and industry (4/5 digit). When we refer to engineers in this report, we mean those in jobs within the engineering occupational footprint. Similarly, when we discuss engineering enterprises, we are referring to organisations whose industrial classification is in the engineering sectoral footprint.

From the outset, our footprint has considered a job or industry to be either fully included or excluded as 'engineering'. We recognise that there are some limitations to this approach. One challenge we face in categorising job and industry codes as engineering or not comes from the level of detail available for each code and the breadth of the codes available. For example, airline pilots might not be considered to be engineers, while flight engineers would be; they are, however, covered by a single code, making it impossible to differentiate one from the other. Another challenge comes when using the model to estimate numbers, as data is not available to the same level of detail – or even at all – for some codes. There are also jobs and industries excluded from the footprint that require some level of engineering competency and may even be vital for the success of the engineering sector: for example, lecturers and teachers of engineering in higher and further education. This is because even at the most detailed SOC level, we are unable to distinguish those teaching engineering and technology subjects from all the other subjects.

Finally, these classifications are created by coding jobs and industries retrospectively, which means that they may not reflect the latest jobs. Bioengineers, for example, work in a relatively new field and don't yet have their own occupational classification code. It is possible that it falls within code 2112: biological scientists and biochemists. However, that code didn't meet our agreed inclusion criteria, so we have not included it in the footprint. For the same reason, the footprint may not capture emerging industry segments. For example, production, transmission and distribution of electricity have their own SIC 2007 codes (3511, 3512, 3513) and are included in the footprint. But there is no distinct code for the storage of electricity, an emerging industry driven by increased use of renewables and the availability of new technology.

2.1 Construction Skills Network. 'Forecasts 2017-2021', 2017, p6.
2.2 Oxford English Dictionary, 2017.
2.3 ONS. 'Standard Occupational Classification 2010 volume 1: structure and descriptions of unit groups', 2010; 'UK SIC 2007', 2007.

It is highly likely that these codes will need to be revised in the next decade to more accurately reflect new jobs and industries. Although SOC codes have typically been revised every 10 years (SOC90, SOC2000, SOC2010), 78% of respondents to a consultation in 2016 thought that an update was needed sooner rather than later.[2.4] SIC codes have been revised 7 times since they were first introduced in 1948,[2.5] and those too may need revising within the next decade. In the meantime, we will necessarily struggle to capture emerging occupations and industry segments.

For these reasons the engineering footprint should be considered as a model rather than an objective listing of all those people and organisations that make up the engineering sectors.

Review of the engineering footprint

The version of the footprint used in this report differs from the version used in the 2017 *State of Engineering*.

Different variants of the footprint have been used by the Engineering Council, Royal Academy of Engineering and EngineeringUK. In 2017, colleagues (including senior representatives) from the Engineering Council, the Royal Academy of Engineering and EngineeringUK formed a panel to review the engineering footprint model. This was done to update the footprint and reach closer agreement between organisations to use a single version.

Previously, EngineeringUK opted to use a binary approach (whereby a sector or occupation was seen to be either in or out of the footprint), while the Engineering Council determined proportions of each SOC classification that may be engineers. For example, in a binary approach, architects are considered to be within engineering, whereas a proportional model might determine that only 30% of architects are included.

In the first instance, the three organisations agreed to standardise on the binary approach, but to improve its precision by further classifying jobs within the footprint as **core** or **related** (**Figure 2.1**). Core engineering footprint jobs were defined as primarily engineering-based roles that require the consistent application of engineering knowledge and skills to execute them effectively. A production and process engineer is one example of a core engineering occupation. Meanwhile, related engineering footprint jobs were defined as those that require a mixed application of engineering knowledge and skill alongside other skill sets, which are often of greater importance to executing the role effectively. An architect is an example of a related engineering occupation.

This is the main difference made to the model between this report and the 2017 report. Core engineering jobs include those that are self-evidently engineering: the engineering professionals 'minor' group of civil, mechanical, electrical, electronics, design and development and production and process engineers. The 'core' definition also includes those that might not primarily be considered engineering but require consistent use of engineering competences, for example 5211: smiths and forge workers. The classification of core or related was only applied to jobs (SOC), not to industries (SIC).

Engineering footprint: rules for inclusion and exclusion

Representatives from EngineeringUK, the Royal Academy of Engineering, and the Engineering Council agreed a set of rules on which to decide which SOC and SIC codes were included in the engineering footprint.

1. Elementary occupations that require no formal training or qualifications were not considered as engineering occupations and all occupations within the level 9 major group elementary occupations were removed
2. All remaining occupations were examined on the following basis:

- Level of qualification required. If no formal qualifications were required above level 2, then:
    - the occupation SOC code skill descriptor was examined - if the panel agreed that there was no clear engineering skills content within the descriptor, the occupation was removed
    - if the panel did not agree, further information was obtained from an external body with specific knowledge of the skills and competencies of the occupations

3. A second element of the classification was to decide whether the occupation should be counted as a 'core' engineering occupation or a 'related' engineering occupation, with the following definitions used:

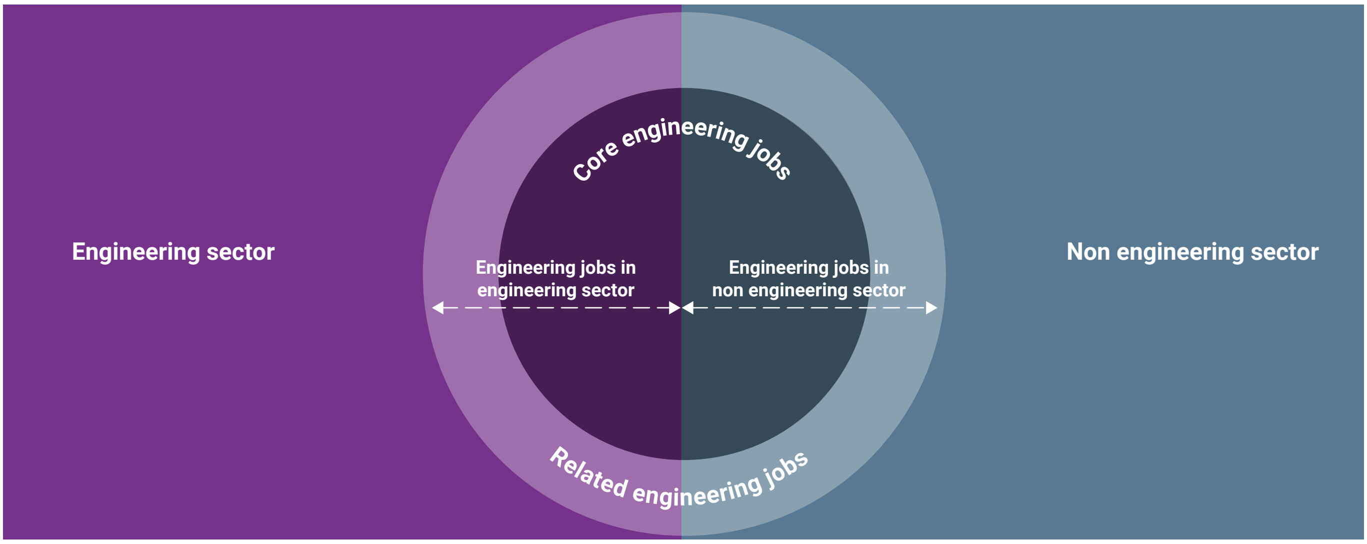
   Core: occupations that are primarily engineering-based and require the consistent application of engineering knowledge and skills to execute the role effectively

   Related: occupations that require a mixed application of engineering knowledge and skill alongside other skill sets, which are often of greater importance to executing the role effectively
4. Where available, the numbers in a given job who were eligible for professional registration as an engineer were taken into consideration by the panel (using information from the Engineering Council's project MERCATOR)
5. Finally, the list of industries (SICs) was reviewed by the panel members, who decided if they should be included or excluded from the footprint model.

As a result of this review, 10 job titles were removed from the footprint, three were added and four remained with input from external organisations. Fourteen industries were removed from the list of SICs and two were added. A full list of SOC and SIC codes within the revised footprint, and more details on the changes made, is available in our Annex.

2.4 ONS. 'Consultation on revising the Standard Occupational Classification 2010 (SOC2010)', 2016.
2.5 ONS. 'UK SIC 2007', 2007.

Figure 2.1 The engineering footprint model



Standard occupational classification (2010)

The standard occupational classification 2010 (SOC2010) has four levels of detail: the highest is major group level, followed by sub-major group, minor group, then unit group. For example:

Major group:	2 Professional occupations
Sub-major group:	21 Science, research, engineering and technology professionals
Minor group:	212 Engineering professionals
Unit group:	2127 Production and process engineers

The engineering footprint uses the most detailed level (unit group), but data can also be analysed at higher levels if necessary.

Standard industrial classification (SIC)

The Standard Industrial Classification 2007 (SIC2007) has four to five levels of detail: the highest is section. This used for grouping and is not required to identify the industry. Industry identification starts at division, then group, then class. Some classes have sub-classes, which is the fifth and most detailed level. For example:

Section:	C Manufacturing
Division:	20 Manufacture of chemicals and chemical products
Group:	20.4 Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
Class:	20.41 Manufacture of soap and detergents, cleaning and polishing preparations
Sub-class:	20.41/1 Manufacture of soap and detergents

Case study – Project MERCATOR

Engineering Council

Project MERCATOR is a research project run by the Engineering Council, designed to estimate the number of engineers eligible for professional registration. It does this by using the ONS Annual Population Survey data, which shows which industries engineers and technicians work in by SIC code. The data also shows the qualifications they have attained and their occupation by SOC code. Using this information, project MERCATOR can estimate the numbers of individuals working in each occupational area who would be eligible to register as:

- Information and Communication Technology Technician (ICTTech)
- Engineering Technician (EngTech)
- Incorporated Engineer (IEng)
- Chartered Engineer (CEng)

By comparing these estimates with the actual number of engineers and technicians registered at each level, the Engineering Council is able to calculate the proportion of the engineering workforce who are registered with them.

Project MERCATOR also uses the Annual Population Survey data to identify where in the UK these engineers work. In addition, it uses data on characteristics, such as gender or ethnicity, to describe the diversity of the engineering workforce.

2.3 – Engineering and UK productivity

The UK's economic performance is a long-standing – and, to some, concerning – point of discussion. As detailed in **Chapter 10**, recent years have seen a substantial increase in the number of people employed and a decline in unemployment. By the end of 2016, GDP, employment, and hours worked were about 7% to 8% higher than the recession in 2008. However, productivity – indicated by how much is produced for a given input, such an hour's work – was no higher. GDP growth has largely been achieved through more hours being worked, rather than through higher productivity. This has resulted in a "low wage, low productivity, high employment outcome." [2.6]

No single theory provides a sufficient explanation for this 'productivity puzzle,' which makes it difficult to predict when – and if – the UK's weakness in productivity growth will come to an end.[2.7] What can be concluded, however, is that with the proportion of people in work at an historic high, only limited economic growth can be achieved by simply recruiting more people. For growth to continue at its recent pace of around 2% per year, the productivity of existing employees needs to be improved.

Engineering has a key role in driving productivity. In addition to employing 18.9% of the UK total workforce – often in highly skilled roles – the sector is integral to the country's ability to innovate, attract investment, and develop infrastructure. As a major beneficiary of vocational and technical education, the engineering sector also has a clear hand in shaping this agenda, and in directly advancing the skills of the workforce through the provision of apprenticeships.

The engineering sector is therefore both integral to achieving, and reliant on, the success of the industrial strategy, which aims to improve productivity. The government's productivity plan[2.8] and industrial strategy [2.9] include aims to improve national infrastructure (transport, energy and digital) and enhance skills, particularly in STEM. The engineering sectors are reliant on and are supporting upskilling, from school to continuing professional development. They also create and benefit from the impact of national infrastructure projects across the UK.

In the 2017 edition of this report, we detailed the significant contribution the engineering sector makes to UK productivity. This was calculated to be a quarter of the UK gross value added. Analysis by Cebr for EngineeringUK (based on the old engineering footprint, but adjusted to reflect the revised footprint) indicated that the engineering sector generated £420.5 billion in 2015. That was more than the Gross Value Added (GVA) generated in 2015 by the retail and wholesale, and financial and insurance sectors combined (£193 billion and £125 billion respectively). [2.10]

Gross valued added (GVA)

The GVA is a measure of the value in the national accounts of an activity. Essentially, it is the value of industrial output minus the value of the intermediate goods and services used as inputs to produce that activity. GVA will be distributed to employees, shareholders and to the government. It is linked as a measurement to GDP (GVA plus taxes, minus subsidies, equals GDP). Taxes and subsidies tend only to be valued at the whole economy level rather than by sector or region, so GVA is a useful measure of a sector or region's contribution to the economic picture.

Figure 2.2 shows the estimated GVA per person per year within the revised EngineeringUK footprint by industry. On average, employees in engineering industries in 2015 generated £74,184 each. Estimates varied significantly between capital intensive engineering industries, such as mining and quarrying (£253,250) and electricity, gas, steam and air conditioning (£139,564), and other engineering industries more reliant on labour, including construction (£64,195) and architecture, security systems and defence (£57,437).

Figure 2.2 Breakdown of projected GVA per person by engineering industry (2015) – UK

Engineering industries	GVA per person (£)
Mining and quarrying	253,250
Manufacturing	68,263
Electricity, gas, steam and air conditioning	139,564
Water supply, sewerage, waste management and remediation	141,301
Scientific research and development	81,429
Construction	64,195
Wholesale, retail, repair of motor vehicles and motorcycles and transport	27,465
IT, telecommunications and other information service activities	94,853
Architecture, security systems, defence	57,437
Other service activities	60,156
All engineering industries	**74,184**

Source: Cebr, 2016
To view this table with total GVA and employment numbers, see **Figure 2.2** in our Excel resource.

It is estimated that every £1 of GVA created by engineering activity generates a further £1.45 of GVA elsewhere. What's more, every additional person employed in engineering is estimated to support another 1.74 jobs.

The importance of engineering to UK productivity is not just its direct contribution but also through the GVA it induces elsewhere. These 'multiplier effects' occur through supply chain activity and the people those organisations in the supply chain employ. It is estimated that every £1 of GVA created by engineering activity, generates a further £1.45 of GVA elsewhere. What's more, every additional person employed in engineering is estimated to support another 1.74 jobs.[2.11]

Other contributions to UK productivity, which are not directly considered in these calculations, are the effects of the engineering sector outputs themselves – for example, the time saved or additional jobs attracted by transport infrastructure such as Crossrail (Elizabeth line) or the Queensferry crossing. These and other major infrastructure engineering projects are discussed later in this chapter.

2.6 OECD. *Glossary of statistical terms; biotechnology, single definition*, 2001.
2.7 BIS. *Cable announces £20 million for UK industrial biotechnology*, February 2015.
2.8 NESTA. *Financing Industrial Biotechnology in the UK*, October 2011.
2.9 OECD. *Synthetic Biology*, November 2010.
2.10 Synbicite. *Synthetic Biology Examples*, 2017.
2.11 Synbicite. *UK Synthetic Biology Start-up Survey*, 2017.

Case study – Economic contribution via the supply chain

Philip Pratley, Director, Trade and External Relations UK, Leonardo

In an increasingly competitive international market, the UK's advanced engineering sector has maintained its successful edge by creating adaptable partnerships across the supply chain. Larger, often transnational, engineering companies work with specialist partners, many of them SMEs, and with academia to create new systems and engineering support services.

Post-Brexit, it is these supply chains, not the larger companies alone, that will be competing internationally. The defining characteristic of the larger companies will be their commitment or otherwise to invest in UK intellectual property, in engineering design and development, in advanced manufacturing infrastructure and in skills in the UK, on their own sites and throughout the supply chain. These will be the features which give the supply chains their resilience internationally, and it is these features which now need to be immediately apparent in the coherence of the UK government's industrial strategy as this emerges from its long gestation into real implementation.

An example of the economic impact of larger engineering companies working with their supply chains for UK and export customers is the UK business of the transnational company Leonardo. Its UK indigenous capability portfolio is in helicopters, RF systems and sensors, data services and cyber. Fifty percent of its £2 billion UK turnover is in exports. With a mature foundation of more than 1,600 UK suppliers, of which over 950 are SMEs, and a strong heritage of its own in companies from Marconi and Ferranti to Westland and Mullard, Leonardo in the UK has achieved strategic contracts from USA to the Middle East, and from Northern Europe to Asia Pacific.

This, in turn, sustains its own workforce of 7,000 highly skilled UK jobs directly and a further 18,000 in the UK supply chain. Independent analysis has shown GVA of 1 to 2.61. This value can be seen in regions of the UK which depend on the success of the company, around its sites in the South West, in central Scotland and in the East of England, and also through the supply chain in other regions. The shared challenge now for both the UK's advanced engineering network and the UK government is to extend to each other the partnership principles of risk management, transparency and long term business planning to be sure of continued success domestically and abroad.

If the GVA multiplier effect of 2.45 is applied to the total engineering GVA estimate of £420.5 billion for 2015, this gives a total impact of £1,030 trillion.

Independent analysis by Cebr[2.12], which estimated the gross value added of the engineering sector by detailed industry, provides a useful indication of the contributions of engineering to the UK economy. In total, the engineering sector created a quarter of the UK's total GVA in 2015 (**Figure 2.3**). Manufacturing was a key industry, generating £156.1 billion GVA in 2015. This was 9.3% of the total UK GVA in 2015. The construction industry generated £62.9 billion and IT, telecommunications and other information service activities £85.4 billion.

If the GVA multiplier effect of 2.45 is applied to the total engineering GVA estimate of £420.5 billion for 2015, this gives a total impact of £1,030 trillion. Similarly, using the old engineering footprint employment of around 5.7 million and employment multiplier of 2.74, we can reasonably estimate that in 2015, 15.6 million people in the UK were supported by the activity of the engineering sectors.[2.13]

Figure 2.3 Breakdown of projected GVA by engineering industry (2015) – UK

Engineering industries	GVA (£ billions)	% of total UK GVA
Mining and quarrying	16.2	1.0%
Manufacturing	156.1	9.3%
Electricity, gas, steam and air conditioning	27.2	1.6%
Water supply, sewerage, waste management and remediation	16.0	0.9%
Scientific research and development	4.0	0.2%
Construction	62.9	3.7%
Wholesale, retail, repair of motor vehicles and motorcycles and transport	8.6	0.5%
IT, telecommunications and other information service activities	85.4	5.1%
Architecture, security systems, defence	42.2	2.5%
Other service activities	1.9	0.1%
All engineering industries	**420.5**	**25.0%**
Non engineering industries	**1,264.5**	**75.0%**
All UK industries	**1,684.9**	**100.0%**

Source: Cebr, 2016
To view this table with numbers by SIC 3-4 digit industry, see **Figure 2.3** in our Excel resource.

2.12 Ibid
2.13 Cebr. 'An updated assessment of the economic contribution of engineering to the UK economy', November 2016.

2.4 – Engineering enterprises

About the data

Analysis in this chapter is primarily on data from the ONS Inter-departmental Business Register (IDBR). Numbers are rounded to the nearest 5. Percentages and numbers may not sum to 100% or the total due to rounding or missing/unknown categories not being included in the figures. Where there are small numbers for some categories, these have been suppressed for data protection. Suppressed numbers are denoted by '–'.

Number of engineering enterprises in the UK

In 2016, the latest year for which data is available, there were 687,575 registered enterprises with SIC classifications in the engineering footprint (**Figure 2.4**). Over a third (239,495) of these were registered in London or the South East. Together, the North East, Yorkshire and the Humber and the North West accounted for 18.7% (128,655) of registered engineering enterprises (**Figure 2.5**). Wales, Northern Ireland and Scotland together had 12.5% (86,225). The South West had 8.7% (59,860) and the Midlands (East and West) and East of England combined had just over a quarter (173,310).

The number of registered engineering enterprises in the UK grew by 5.6% between 2015 and 2016. This equated to 36,495 new engineering enterprises. This increase varied between 3.5% and 5.8% in each devolved administration or English region, except in London, which increased by 10.2% (11,310 new enterprises). Over the 5 years from 2011 to 2016, there were double digit percentage increases in each region and country, except Northern Ireland. For the UK, this increase was over a quarter at 26.8%. Growth in terms of number of enterprises was particularly high in London (54.3%), the North East (33.9%), and Scotland (29.6%).

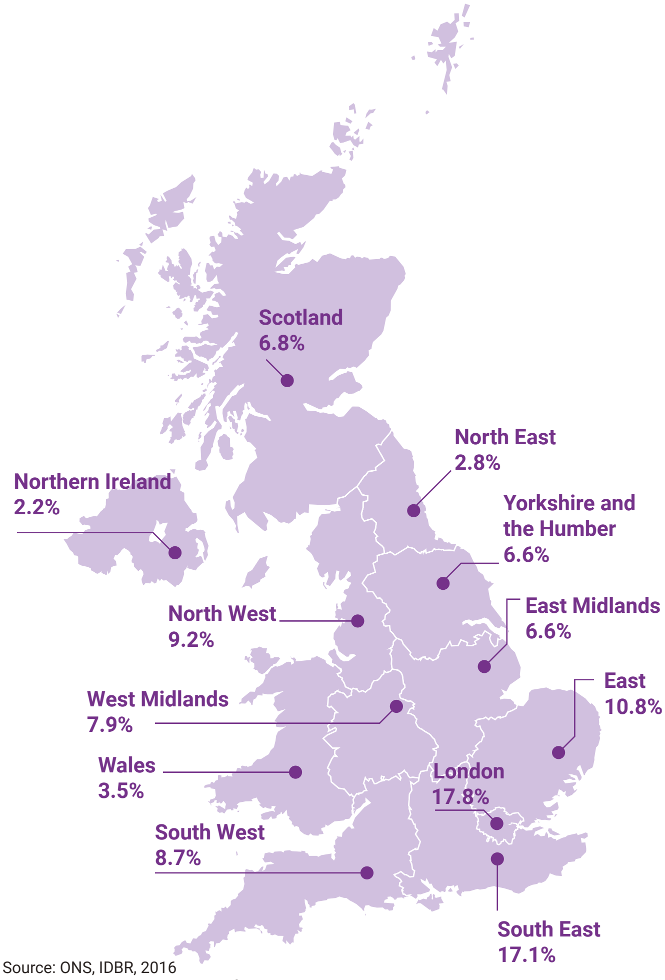
Figure 2.4 Number of VAT and/or PAYE registered engineering enterprises by nation/region (2016) – UK

Nation/region	No.	%	Change over 1 year (%)	Change over 5 years (%)
England	601,320	87.5%	5.8% ▲	27.6% ▲
North East	19,470	2.8%	4.5% ▲	33.9% ▲
North West	63,480	9.2%	4.5% ▲	23.6% ▲
Yorkshire and the Humber	45,705	6.6%	3.9% ▲	21.0% ▲
East Midlands	45,155	6.6%	4.6% ▲	18.6% ▲
West Midlands	54,140	7.9%	5.3% ▲	20.5% ▲
East	74,015	10.8%	5.3% ▲	22.3% ▲
London	122,200	17.8%	10.2% ▲	54.3% ▲
South East	117,295	17.1%	5.2% ▲	24.1% ▲
South West	59,860	8.7%	4.0% ▲	18.9% ▲
Wales	24,145	3.5%	4.2% ▲	20.0% ▲
Scotland	46,880	6.8%	3.5% ▲	29.6% ▲
Northern Ireland	15,230	2.2%	5.6% ▲	2.4% ▲
UK	**687,575**	**100.0%**	**5.6% ▲**	**26.8% ▲**

Source: ONS, IDBR, 2011 to 2016
To view this table with numbers from 2011, see **Figure 2.4** in our Excel resource.

Over a quarter of the 2.5 million registered enterprises in the UK were in the engineering footprint (26.9%).

Figure 2.5 Distribution of VAT and/or PAYE registered engineering enterprises in 2016, by UK nation and region



Source: ONS, IDBR, 2016
To view this chart with numbers from 2011, see **Figure 2.5** in our Excel resource.

Over a quarter (26.9% or 687,575) of the 2.55 million (2,554,510) registered enterprises in the UK were in the engineering footprint.

This proportion increased marginally, by 0.3 percentage points, between 2015 and 2016 and by 0.8 percentage points between 2011 and 2016. In 2016, in the English regions and constituent countries of the UK, the proportion of engineering enterprises varied from 22.0% in Wales and 24.2% in Northern Ireland, to 29.1% in the East of England and 29.9% in the South East and 28.7% in the North East.

Figure 2.6 Number of VAT and/or PAYE registered engineering enterprises as a proportion of all enterprises (2016) – UK

Nation/region	Number of all enterprises	Number of engineering enterprises	Percentage engineering enterprises	Change over 1 year (%p)	Change over 5 years (%p)
England	2,213,655	601,320	27.2%	0.3%p ▲	0.7%p ▲
North East	67,800	19,470	28.7%	0.4%p ▲	2.2%p ▲
North West	245,170	63,480	25.9%	0.1%p ▲	0.3%p ▲
Yorkshire and the Humber	177,930	45,705	25.7%	0.2%p ▲	-0.1%p ▼
East Midlands	172,700	45,155	26.1%	-0.1%p ▼	-0.9%p ▼
West Midlands	200,550	54,140	27.0%	0.2%p ▲	0.2%p ▲
East	253,955	74,015	29.1%	0.2%p ▲	0.5%p ▲
London	476,890	122,200	25.6%	0.7%p ▲	1.9%p ▲
South East	392,085	117,295	29.9%	0.4%p ▲	1.1%p ▲
South West	226,575	59,860	26.4%	0.3%p ▲	0.8%p ▲
Wales	69,095	15,230	22.0%	0.5%p ▲	1.2%p ▲
Scotland	171,900	46,880	27.3%	0.4%p ▲	2.3%p ▲
Northern Ireland	99,860	24,145	24.2%	0.5%p ▲	0.2%p ▲
UK	**2,554,510**	**687,575**	**26.9%**	**0.3%p ▲**	**0.8%p ▲**

Source: ONS, IDBR, 2011 to 2016
To view this table with numbers from 2011, see **Figure 2.6** in our Excel resource.

In the UK, the proportion of enterprises classed as 'engineering' has increased by less than a percentage point over both 1 year and the last 5 years (**Figure 2.6**). In the last year, the only decrease was in the East Midlands, which fell by just 0.1 percentage point. This was driven by the growth of non-engineering enterprises between 2015 and 2016 outpacing the growth of engineering enterprises, rather than by an absolute decrease in engineering enterprises in the region. This was part of a slightly larger decline (0.9 percentage points) over the previous 5 years, as non-engineering enterprises increased at a slightly higher rate. There was also a marginal decrease in Yorkshire and the Humber of 0.1 percentage points for the same reason. The proportion of engineering enterprises increased by 2.3 percentage points in Scotland and by 2.2 percentage points in the North East. The proportion of engineering enterprises in London increased by 1.9 percentage points.

The number of engineering enterprises in the different broad industrial groupings by region/nation is shown in **Figure 2.7**. Overall, information and communications comprised the largest proportion of engineering enterprises in the UK (29.2%). This was followed by construction (26.3%) and manufacturing (19.1%). The remaining quarter of engineering enterprises were from other industrial groups such as:

- production of electricity to maintenance and repair of motor vehicles
- data processing, hosting and other activities
- engineering design activities for industrial process and production

There were only 1,185 mining and quarrying enterprises in the UK. The largest proportion were in Scotland (20.7%), followed by London (13.1%), then the South East, South West (8.0% each), then Yorkshire and the Humber (8.0%).

Manufacturing had over a 100 times more enterprises in 2016 than mining and quarrying (131, 530 compared with 1,185). The largest proportion were in the South East (13.9%), followed by the North West (11.0%), West Midlands (10.9%) and East of England (10.4%). Yorkshire and the Humber, the East Midlands, London and the South West each had a 9.0 to 9.1% share of UK manufacturing enterprises.

At 180,510, there were almost 50,000 more construction enterprises than manufacturing enterprises in 2016. These were concentrated in southern and eastern England, led by the South East (16.9%), then London (13.6%), the East of England (12.4%) and the South West (9.8%). The North West had 8.9% of the construction enterprises in the UK and the highest proportion across the Midlands and northern UK.

Information and communication had the most enterprises of any engineering industry, at 200,750. These were even more concentrated than construction in south eastern England. Nearly a third were in London (30.8%), a fifth were in the South East (20.6%), and a further 10.2% were in the East of England.

Enterprises in the remaining industrial groups in the engineering footprint were less focused on southern and eastern England. The South East had the highest proportion (15.6%), followed by London (13.2%), then the North West (10.7%) and the East of England (10.1%). The South West had 8.7% of the enterprises in the remaining industrial groups.

Figure 2.7 Number of VAT and/or PAYE registered engineering enterprises by selected industry and region/nation (2016)

Nation/region	Mining and quarrying	Manufacturing	Construction	Information and communications	All other industrial groups	Total engineering sector
England	785	113,380	155,605	185,510	146,040	601,320
North East	45	4,240	5,155	2,965	7,065	19,470
North West	70	14,465	16,110	14,200	18,635	63,480
Yorkshire and the Humber	95	11,810	13,000	9,010	11,790	45,705
East Midlands	80	12,010	12,830	8,825	11,410	45,155
West Midlands	55	14,385	13,555	11,755	14,390	54,140
East	85	13,640	22,370	20,425	17,495	74,015
London	155	12,675	24,485	61,905	22,980	122,200
South East	100	18,235	30,445	41,400	27,115	117,295
South West	100	11,920	17,655	15,025	15,160	59,860
Northern Ireland	90	3,870	6,235	1,620	3,415	15,230
Scotland	245	8,655	10,850	9,495	17,635	46,880
Wales	65	5,625	7,820	4,125	6,510	24,145
UK	**1,185**	**131,530**	**180,510**	**200,750**	**173,600**	**687,575**
Percentage of engineering sector	**0.2%**	**19.1%**	**26.3%**	**29.2%**	**25.2%**	**100.0%**

Source: ONS, IDBR, 2016
To view this table with numbers from 2011 and by enterprise size, see **Figure 2.7** in our Excel resource.

Figure 2.8 Engineering enterprises registered for VAT and/or PAYE by industry (2016) – UK

Engineering industries	No.	Change over 1 year (%)	Change over 5 years (%)
Agriculture, forestry and fishing	65	18.2% ▲	85.7% ▲
Mining and quarrying	1,185	0.0%	6.8% ▲
Manufacturing	131,530	2.4% ▲	8.9% ▲
Electricity, gas, steam and air conditioning supply	3,940	28.3% ▲	510.9% ▲
Water supply; sewerage, waste management and remediation services	4,855	2.4% ▲	20.3% ▲
Construction	180,510	6.3% ▲	18.4% ▲
Wholesale and retail trade; repair of motor vehicles	42,590	3.4% ▲	20.8% ▲
Transportation and storage	10	0.0%	0.0%
Information and communications	200,750	7.6% ▲	40.8% ▲
Professional, scientific and technical activities	113,705	5.6% ▲	43.6% ▲
Administrative and support service activities	2,070	4.8% ▲	48.9% ▲
Public administration and defence; compulsory social security	25	0.0%	25.0% ▲
Other service activities	6,340	2.3% ▲	27.3% ▲
All engineering industries	**687,575**	**5.6% ▲**	**26.8% ▲**
All industries	**2,554,510**	**4.3% ▲**	**22.8% ▲**

Source: ONS, IDBR, 2011 to 2016
To view this table with numbers from 2012 see **Figure 2.8** in our Excel resource.

Overall, the proportion of engineering enterprises increased by 5.6% over 1 year – although there was variation across the sectors (**Figure 2.8**). For some, there was no increase. Encouragingly, however, no industries decreased in number of enterprises over either the last 1 year or 5 years. The largest increase within the major engineering industries was information and communication, which grew by 7.6% over 1 year and 40.8% over 5 years. In 2011 there were 142,585 information and communications enterprises. Examples of developing industries, given later in this section, show many are within information and communication.

Size of engineering enterprises

Across all industry sectors in the UK, 89.2% of enterprises in 2016 were micro-sized (0 to 9 staff), 8.9% had 10 to 49 employees and a further 1.6% were medium sized (50 to 249 employees). Overall, 99.6% classed as small or medium enterprises (SMEs). Only 0.4% of enterprises were classed as large, with 250 or more employees. The enterprises in the engineering footprint reflect a similar profile, with a slightly higher proportion of micro enterprises (90.6%) and, correspondingly, lower proportions of all other enterprise sizes (**Figure 2.9**).

Of the major engineering industries, information and communications saw the largest growth in terms of enterprise numbers, increasing by 7.6% over one year and 40.8% over five years.

Figure 2.9 Engineering industries by enterprise size (2016) – UK

Engineering industries	0-9	10-49	50-249	Total SME (0-249)	250+	Total no.
Agriculture, forestry and fishing	76.9%	15.4%	7.7%	100.0%	0.0%	65
Mining and quarrying	72.3%	18.1%	5.5%	95.8%	4.2%	1,190
Manufacturing	77.9%	16.7%	4.5%	99.1%	0.9%	131,530
Electricity, gas, steam and air conditioning supply	90.6%	7.9%	0.8%	99.2%	0.8%	3,940
Water supply; sewerage, waste management and remediation services	77.0%	18.3%	3.8%	99.2%	0.8%	4,855
Construction	92.9%	6.1%	0.8%	99.9%	0.1%	180,510
Wholesale and retail trade; repair of motor vehicles	92.6%	6.8%	0.5%	99.9%	0.1%	42,590
Transportation and storage	50.0%	0.0%	0.0%	50.0%	50.0%	10
Information and communications	94.8%	4.3%	0.8%	99.8%	0.2%	200,745
Professional, scientific and technical activities	94.1%	4.9%	0.8%	99.8%	0.2%	113,705
Administrative and support service activities	91.8%	7.2%	1.0%	100.0%	0.0%	2,070
Public administration and defence; compulsory social security	20.0%	40.0%	40.0%	100.0%	0.0%	25
Other service activities	93.9%	5.0%	0.9%	99.8%	0.2%	6,340
All engineering industries	**90.6%**	**7.5%**	**1.5%**	**99.7%**	**0.3%**	**687,575**
All industries	**89.2%**	**8.9%**	**1.6%**	**99.6%**	**0.4%**	**2,554,510**

Source: ONS, IDBR, 2016
To view this table with numbers from 2011 see Figure 2.9 in our Excel resource.

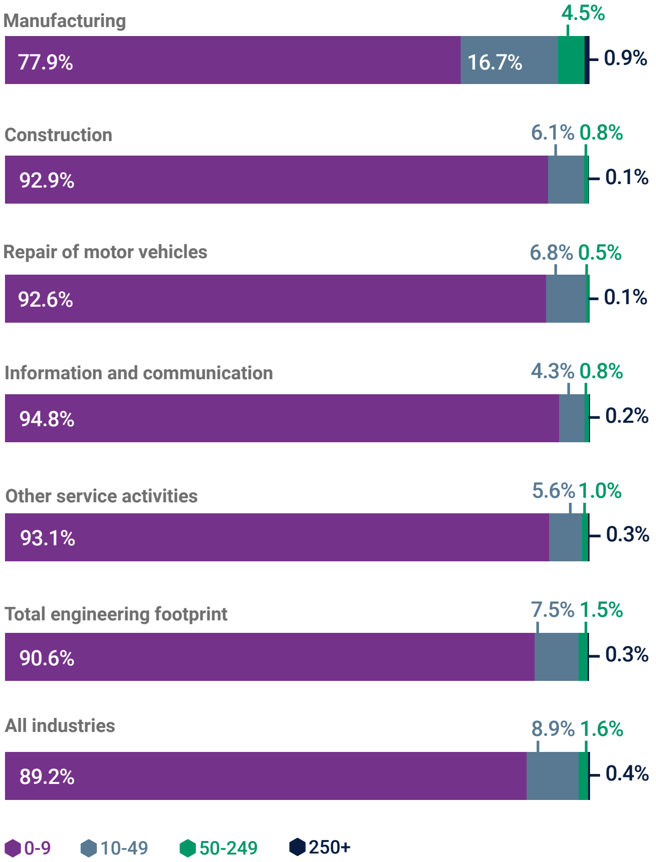
However, Figure 2.9 and Figure 2.10 also show that, while micro enterprises dominate the engineering sector as a whole, these are concentrated in specific industries: namely, construction; repair of motor vehicles; information and communication; and professional, scientific and technical activities. Conversely, manufacturing, agriculture, forestry and fishing, mining and quarrying, water supply, and transportation and storage had relatively low proportions of micro enterprises.

Manufacturing, agriculture, forestry and fishing, mining and quarrying, and water supply, also all had higher proportions of small and medium sized enterprises. The relatively few large enterprises were more often in manufacturing, water supply, electricity supply, and mining and quarrying.

The number of engineering enterprises has increased by over a quarter 2011 to 2016 (26.8%, Figure 2.4). This trend may partly be explained by an increasing number of micro or small sized enterprises in emerging industries, particularly in information and communications.

The number of engineering enterprises increased by 26.8% between 2011 and 2016. This is in part due to the growing number of micro or small sized enterprises in emerging industries. In 2016, 90.6% of engineering enterprises had less than 10 employees.

Figure 2.10 Engineering industries by enterprise size (2016) – UK



Source: ONS, IDBR, 2016
To view this chart with numbers from 2011, see **Figure 2.10** in our Excel resource.

By nation or region, Yorkshire and the Humber, the East Midlands and the West Midlands had lower proportions of micro enterprises in the engineering footprint and higher proportions of small, medium and large sized enterprises. These regions also had slightly higher proportions of manufacturing enterprises than other UK countries or regions (see our Excel resource).

The North East and Wales also had slightly higher than average proportions of medium and large engineering enterprises. The North East had a higher share of those industries tending towards medium and large enterprises (manufacturing, and quarrying and mining), compared to its share of industries with more micro enterprises (information and communication, and construction). In Wales, there was a relatively high proportion of manufacturing enterprises, which tended to be small or medium, a lower proportion of enterprises in information and communication (mostly micro enterprises) and a higher proportion of construction enterprises (also micro).

In contrast, London had a higher proportion of micro enterprises than the rest of the engineering footprint (**Figure 2.11**). As noted earlier, London had a concentration of enterprises in information and communication and in construction, both of which had high proportions of micro enterprises. When aggregated to SME level, the regional and country variations all but disappear, with only 0.2 percentage points between the lowest and highest.

Figure 2.11 Engineering sector by enterprise size and nation/region (2016)

Nation/region	0-9	10-49	50-249	Total SME (0-249)	250+	Total no.
England	90.7%	7.5%	1.5%	99.7%	0.3%	601,320
North East	89.0%	8.5%	2.1%	99.6%	0.4%	19,470
North West	89.2%	8.6%	1.8%	99.7%	0.3%	63,475
Yorkshire and the Humber	87.6%	9.7%	2.2%	99.6%	0.4%	45,705
East Midlands	88.4%	9.2%	2.0%	99.6%	0.4%	45,155
West Midlands	88.3%	9.4%	1.9%	99.6%	0.4%	54,140
East	91.2%	7.1%	1.4%	99.7%	0.3%	74,015
London	93.5%	5.3%	1.0%	99.8%	0.2%	122,205
South East	91.9%	6.6%	1.2%	99.7%	0.3%	117,295
South West	90.8%	7.6%	1.3%	99.7%	0.3%	59,860
Wales	89.7%	8.0%	2.0%	99.6%	0.4%	24,145
Scotland	89.8%	7.9%	1.8%	99.6%	0.4%	46,880
Northern Ireland	88.8%	9.0%	1.9%	99.7%	0.3%	15,230
UK	**90.6%**	**7.5%**	**1.5%**	**99.7%**	**0.3%**	**687,575**

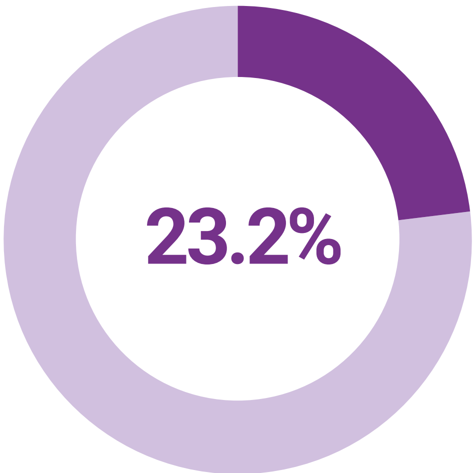
Source: ONS, IDBR, 2016
To view this table with numbers from 2011 see **Figure 2.11** in our Excel resource.

2.5 – Engineering enterprise turnover

Turnover, the amount derived from goods and services after tax, gives an indication of the size of enterprises and the industries and sectors they operate in. Engineering enterprises registered for VAT and/or PAYE in the UK generated 23.2% (£1.23 trillion[2.14]) of the UK's £5.3 trillion total turnover from all registered enterprises for the financial year March 2015 to March 2016 (**Figure 2.12**). The total turnover itself had grown by 3.2% in the same period (**Figure 2.17**).

Engineering enterprises registered for VAT and/or PAYE in the UK generated 23.2% (£1.23 trillion) of the UK's £5.3 trillion total turnover.

Figure 2.12 Engineering enterprise share of turnover in all VAT and/or PAYE registered enterprises (2016) – UK



Source: ONS, IDBR, 2016
To view this chart with numbers from 2011, see **Figure 2.12** in our Excel resource.

Engineering enterprise turnover by region

Analysis by UK nation and English region (**Figure 2.13**) shows that London and South East England accounted for the largest engineering turnovers (£238 billion and £225 billion respectively). Between them, London (19.4%), the South East (18.3%), the West Midlands (10.9%) and Scotland (9.4%) accounted for over half of engineering enterprise turnover.

However, overall engineering turnover declined compared with 2015. Turnover in London was 1% lower than the year before and in the South East it dropped by 9% in 2015 to 2016. The decline in turnover in London and the South East – the regions with the two highest levels of engineering employment – together with a decrease in the South West, effectively cancelled the growth in all the other regions in England, to cause a decrease of 1.4% in England and of 0.7% in the UK.

Between 2011 and 2016, every UK constituent country and English region saw double digit percentage increases in turnover, except the East of England (1.5%) and the South East (-2.2%). Most of these increases were between 16% and 23%. The highest was in the West Midlands (74%), where the share of engineering enterprise turnover was 10.9%. Although this presents an apparently healthy picture overall, it should be remembered that this data covers the UK's emergence from the recession, and much of this growth could represent recovery to pre-2008 levels. Also notable is the dip in turnover in 2011 across much of the north of England and Wales. Nevertheless, that turnover across all countries and regions was higher in 2016 than 2009 indicates the sector has recovered from the financial crisis.

Figure 2.13 Turnover in VAT and/or PAYE registered engineering enterprises by nation/region (2016) – UK

Nation/region	Share of engineering turnover (%)	Turnover (£ billions)	Change over 1 year (%)	Change over 5 years (%)
England	85.9%	1,055.6	-1.4% ▼	15.9% ▲
North East	2.6%	31.7	4.0% ▲	17.2% ▲
North West	7.8%	95.3	0.8% ▲	22.4% ▲
Yorkshire and the Humber	5.6%	69.1	4.4% ▲	22.5% ▲
East Midlands	5.9%	71.9	3.6% ▲	22.4% ▲
West Midlands	10.9%	134.1	2.1% ▲	74.0% ▲
East	9.0%	110.9	2.3% ▲	1.5% ▲
London	19.4%	238.4	-1.0% ▼	15.0% ▲
South East	18.3%	225.3	-9.1% ▼	-2.2% ▼
South West	6.4%	79.0	-3.0% ▼	17.4% ▲
Wales	3.0%	37.2	5.8% ▲	15.8% ▲
Scotland	9.4%	116.1	2.7% ▲	17.5% ▲
Northern Ireland	1.6%	20.1	3.3% ▲	11.1% ▲
UK	**100.0%**	**1,229.1**	**-0.7% ▼**	**15.9% ▲**

Source: ONS, IDBR, 2011 to 2016
To view this table with numbers from 2011, see **Figure 2.13** in our Excel resource.

2.14 £1,230,000,000,000

Engineering as a share of total turnover

Between 2015 and 2016, the contribution of engineering as a proportion of all turnover decreased by nearly 1 percentage point, to 23.2% of all enterprise turnover (**Figure 2.14**). It is worth noting, however, that this UK average is skewed by the low figure (11.8%) in London, where engineering turnover is overshadowed by the service sectors. Across other English regions and the constituent nations of the UK, engineering typically generated between a quarter to a third of turnover in their respective regions. Even in Yorkshire and the Humber, the region with the lowest share of turnover other than London, it stood at 20.5%. The share of turnover was highest in Wales (38.8%) and the West Midlands (40.2%). While the value of engineering enterprise turnover in Northern Ireland was relatively small at £20 million, as a share of total turnover, this was 29.6% (as we show in our Excel resource).

Engineering turnover as a share of the total saw minimal change between March 2015 and March 2016, with changes of one percentage point or less across most regions. There were two exceptions: engineering share of the turnover decreased in the South West by 1.9 percentage points and in the South East by 3 percentage points. Changes are more apparent when looking at the five-year period since 2011. Although engineering turnover as a share of total turnover decreased by 0.7% percentage points nationally, the West Midlands, South West and Scotland saw increases of between 5 and 7 percentage points. The share in the North East also increased by 2.5%. The overall decrease observed at the UK level was largely driven by the substantial decrease in the South East (8 percentage points). Wales and the North West also saw decreases of about 2 percentage points between 2011 and 2016.

Figure 2.14 Engineering enterprise share of turnover of all VAT and/or PAYE registered enterprises by nation/region (2016) – UK

Nation/region	Turnover	Change over 1 year (%p)	Change over 5 years (%p)
England	22.1%	-1.0%p ▼	-1.0%p ▼
North East	30.5%	1.0%p ▲	2.5%p ▲
North West	28.2%	-0.9%p ▼	-1.7%p ▼
Yorkshire and the Humber	20.5%	0.3%p ▲	0.9%p ▲
East Midlands	29.6%	0.5%p ▲	0.9%p ▲
West Midlands	40.2%	0.4%p ▲	6.9%p ▲
East	28.6%	-0.8%p ▼	0.7%p ▲
London	11.8%	-0.7%p ▼	-1.3%p ▼
South East	30.9%	-3.0%p ▼	-8.4%p ▼
South West	27.1%	-1.9%p ▼	5.1%p ▲
Wales	38.8%	0.3%p ▲	-2.3%p ▼
Scotland	33.9%	0.4%p ▲	5.1%p ▲
Northern Ireland	29.6%	0.0%p ▲	0.2%p ▲
UK	**23.2%**	**-0.9%p ▼**	**-0.7%p ▼**

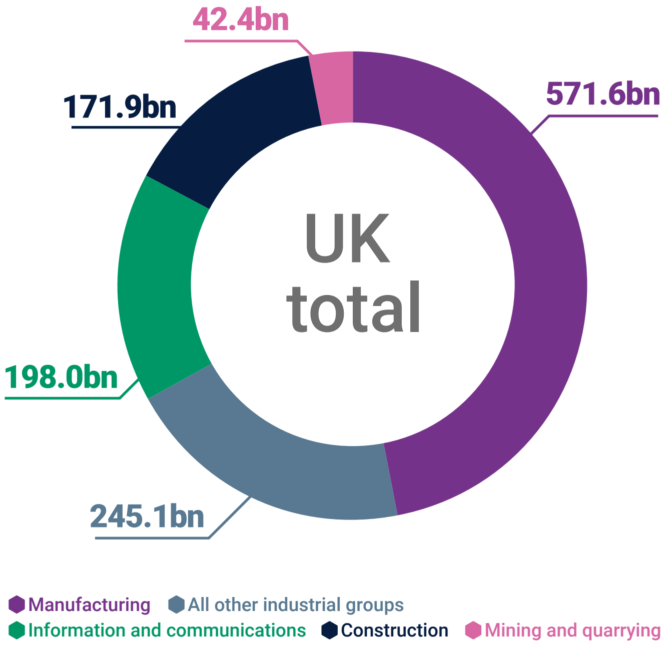
Source: ONS, IDBR, 2011 to 2016
To view this table with numbers from 2011, see **Figure 2.14** in our Excel resource.

Engineering enterprises turnover by industry

With a value of £572 billion, manufacturing accounted for nearly half (46.5%) of the turnover of engineering enterprises in 2016 (**Figure 2.15**). The next two largest industries by turnover were information and communication (16.1%, £198 billion) and construction (14.0%, £172 billion).

The rest were below 10% (**Figure 2.16**). Some engineering enterprises generated a very low proportion of turnover in 2016, perhaps reflecting their comparatively small size. Agriculture, forestry and fishing accounted for just 0.02% (£187 million) and transportation and storage only 0.07% (£883 million). Nevertheless, their turnovers were still hundreds of millions and their services and outputs are necessary for other industries, with higher turnovers, to function.

Figure 2.15 Top engineering industries by turnover in 2016 – UK



Source: ONS, IDBR, 2016

Manufacturing accounted for 46.5% of turnover generated by engineering enterprises in 2016. The information and communications and construction industries also constituted a sizeable share of turnover (16.1% and 14.0%, respectively).

Figure 2.16 Percentage share of turnover in VAT and/or PAYE registered engineering enterprises by industry (2016) – UK

Engineering industries	Turnover (%)
Agriculture, forestry and fishing	0.0%
Mining and quarrying	3.5%
Manufacturing	46.5%
Electricity, gas, steam and air conditioning supply	8.1%
Water supply; sewerage, waste management and remediation	2.0%
Construction	14.0%
Wholesale and retail trade; repair of motor vehicles	1.9%
Transportation and storage	0.1%
Information and communication	16.1%
Professional, scientific and technical activities	7.3%
Administrative and support service activities	0.1%
Public administration and defence; compulsory social security	0.1%
Other service activities	0.4%
All engineering Industries	**100.0%**

Source: ONS/IDBR, 2016
To view this table with numbers from 2011, see **Figure 2.16** in our Excel resource.

While turnover in the engineering sector declined by 0.7% between 2015 and 2016, it increased in non engineering industries by 4.5%. Over 5 years, (2011 to 2016) the increase in turnover by enterprises in engineering industries was outpaced by those in non engineering industries (15.9% versus 20.5%) (**Figure 2.17**).

The – admittedly slight – decline in turnover between 2015 and 2016 was largely driven by a decrease in the turnover generated by manufacturing (down 2.7%), which comprises 19.1% of engineering enterprises. Turnover for the next two biggest industries actually increased. Information and communication turnover increased by 5.0% and construction by 11.5%. There were relatively big declines in turnover for agriculture forestry and fishing (down 25.9%), mining and quarrying (down 15.7%), electricity, gas, steam and air conditioning supply (down 17.3%), and in public administration and defence (down 17.0%).

Turnover trends over the 5 year period between 2011 and 2016 show a more positive picture. In that period, manufacturing turnover increased by 22.6% and information and communication by 23.5%. Turnover in construction enterprises also increased by 15.8%. Turnover for some of the smaller industries, such as professional, scientific and technical activities and wholesale/retail trade and repair of motor vehicles, also saw sizeable increases in turnover (33.6% and 30.8% respectively).

However, some industries saw a decline in turnover between 2011 and 2016. Mining and quarrying, for example, saw a decrease of 40.3%. Electricity, gas, steam and air conditioning supply industry also saw a less dramatic decrease of 1.4% between 2011 and 2016.

Engineering enterprise turnover by region and industry

Our Excel resource shows turnover for the main engineering industries by UK nations and English region as at March 2009 to 2016. This is summarised in **Figure 2.18**.

In 2016, much manufacturing was concentrated in London (£69.1 billion), the South East (£96.3 billion), the West Midlands (£91.9 billion) and, the North West (£54.2 billion). Manufacturing was the industry with the highest turnover in Wales (£25.1 billion), Northern Ireland (£10.8 billion), the South West (£34.3 billion), the North East (£19.5 billion) and Yorkshire and the Humber (£38.7 billion).

Information and communication was focused in London (£82.1 billion) and the South East (£60.8 billion). Construction was concentrated in London (£26.1 billion), the South East (£33.6 billion), the East of England (£23.4 billion) and the East Midlands (£14.2 billion).

Considerable turnover was concentrated in London, including in mining and quarrying (£20.3 billion). It is possible this is due to many enterprises' head offices being registered in London.

Figure 2.17 Turnover in VAT and/or PAYE registered engineering enterprises by industry (2016) – UK

Engineering industries	Turnover (£ billions)	Change over 1 year (%)	Change over 5 years (%)
Agriculture, forestry and fishing	0.2	-25.9% ▼	–
Mining and quarrying	42.4	-15.7% ▼	-40.3% ▼
Manufacturing	571.6	-2.7% ▼	22.6% ▲
Electricity, gas, steam and air conditioning supply	99.2	-17.3% ▼	-1.4% ▼
Water supply; sewerage, waste management and remediation	24.5	-4.0% ▼	16.6% ▲
Construction	171.9	11.5% ▲	15.8% ▲
Wholesale and retail trade; repair of motor vehicles	23.7	0.7% ▲	30.8% ▲
Transportation and storage	0.9	4.9% ▲	–
Information and communication	198.0	5.0% ▲	23.5% ▲
Professional, scientific and technical activities	89.1	10.0% ▲	33.6% ▲
Administrative and support service activities	0.9	4.1% ▲	109.7% ▲
Public administration and defence; compulsory social security	1.3	-17.0% ▼	–
Other service activities	5.4	27.3% ▲	62.0% ▲
All engineering industries	**1,229.1**	**-0.7%** ▼	**15.9%** ▲
Non engineering industries	**4,061.6**	**4.5%** ▲	**20.5%** ▲
All industries	**5,290.7**	**3.2%** ▲	**19.4%** ▲

Source: ONS, IDBR, 2011 to 2016
To view this table with numbers from 2011, see **Figure 2.17** in our Excel resource.
'–' denotes low values which have been suppressed.

Figure 2.18 Share of total turnover generated by VAT and/or PAYE registered engineering enterprises (in £ billions) by industry and nation/region (2016) – UK

	Mining and quarrying	Manufacturing	Construction	Information and communications	All other industrial groups	Total engineering sector
England	26.9	505.0	151.1	191.7	181.0	1,055.6
North East	0.5	19.5	5.3	1.3	5.1	31.7
North West	0.4	54.2	11.9	8.5	20.2	95.3
Yorkshire and the Humber	0.5	38.7	13.0	4.3	12.6	69.1
East Midlands	2.2	44.8	14.2	3.9	6.9	71.9
West Midlands	0.4	91.9	12.8	6.0	22.9	134.1
East	0.2	56.2	23.4	11.8	19.3	110.9
London	20.3	69.1	26.1	82.1	40.7	238.4
South East	1.9	96.3	33.6	60.8	32.7	225.3
South West	0.3	34.3	10.7	13.0	20.6	79.0
Wales	0.3	25.1	5.2	1.4	5.2	37.2
Scotland	15.1	30.6	10.9	4.0	55.6	116.1
Northern Ireland	0.2	10.8	4.7	0.9	3.4	20.1
UK	**42.4**	**571.6**	**171.9**	**198.0**	**245.1**	**1,229.1**

Source: ONS, IDBR, 2016
To view this table with numbers from 2011, see **Figure 2.18** in our Excel resource.

2.6 – Developments and emerging industries

The engineering sector is diverse and dynamic, with enterprises developing products ranging from synthetic biology to smart motorways or artificial intelligence. For the reasons explained in the previous section, the industries are covered by area rather than exact SIC 2007 code. This section is not intended to be exhaustive, but rather serves to highlight some of the developments across the engineering industries and a few of the outputs they create. It also indicates some of the emerging industries and reflects on expected future skills shortages.[2.15]

Where helpful, we have provided figures such as employment numbers or turnover as an indication of the market size or potential of an emerging industry. Section 2.7 goes into more detail on specific examples of infrastructure projects, with indications of their economic contribution.

Biotechnology, nanotechnology, bio-medical engineering and land-based engineering

Biotechnology

Biotechnology is: *"the application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services".* [2.15]

It includes healthcare biotechnology and industrial biotechnology. Industrial biotechnology is forecast to be worth up to £12 billion by 2025.[2.16] Applications range from the production of fuels (such as bioethanol), to food or material production and waste management.[2.17]

Synthetic biology comes under biotechnology and is the "… design and construction of new biological parts, devices, and systems" or the "redesign of existing, natural biological systems for useful purposes" [2.18] such as the production of medical vaccines or flavours for food products.[2.19] Between 2009 and 2016, the UK government invested £300 million in synthetic biology. In 2016, there were 111 active synthetic biology start-ups that had raised £620 million in investment funding between them.[2.20]

Nanotechnology

Nanotechnology is the "… set of technologies that enables the manipulation, study or exploitation of very small (typically less than 100 nanometres) structures and systems".[2.21] It spreads across a number of fields, from electronics such as semiconductors, to materials like graphene. While the considerable investor excitement in nanotech start-ups in the mid-2000s has declined somewhat, the industry is still developing.[2.22] One UK example is Graphene Composites Ltd, based in Sedgefield in North East England. It is working to combine graphene and aerogel to produce aircraft skins, 'ultra-strong' cables and ballistic armour.[2.23] Another application is the use of nanoparticles as ultraviolet light filters in sunscreen. [2.24]

2.15 OECD. 'Glossary of statistical terms; biotechnology, single definition', 2001.
2.16 BIS. 'Cable announces £20 million for UK industrial biotechnology', February 2015.
2.17 NESTA. 'Financing Industrial Biotechnology in the UK', October 2011.
2.18 OECD. 'Synthetic Biology', November 2010.
2.19 Synbicite. 'Synthetic Biology Examples', 2017.
2.20 Synbicite. 'UK Synthetic Biology Start-up Survey', 2017.
2.21 OECD. 'Science and Technology Policy: Nanotechnology', 2017.
2.22 Time. 'Here's Why Nobody's Talking About Nanotech Anymore', October 2015.
2.23 Graphene Composites Ltd. 'Welcome to GCL', 2017.
2.24 The Guardian. 'The nanotechnology in your sunscreen', February 2014.

Biomedical engineering

Biomedical engineering covers the design, testing and maintenance of medical devices and equipment, from sticking plasters, to cardiac pacemakers and prosthetics, to medical scanners and incubators. The UK medical technology market has 3,700 enterprises employing 115,000 people.[2.25] The UK government estimates the UK medical technology market to be the third largest market in Europe, at £7.6 billion.

Demographic changes such as an aging population and the prevalence of chronic and communicable diseases are expected to further fuel increased demand. Global healthcare spend is predicted to reach $8.7 trillion by 2020.[2.26] The UK government's industrial strategy white paper, Building a Britain *fit for the future*, [2.27] and the Life Sciences Sector Deal [2.28] seek to capitalise on this position and ensure the industry is ready to capitalise on this for the future.

At the intersection of medical devices and 'the internet of things', is the connected healthcare market. Examples include wearable activity trackers and blood pressure monitors. Accountancy and consultancy firm PricewaterhouseCooper (PwC) has forecasted the global market for this to increase by a third each year, reaching £37 billion by 2020. It is thought the UK will capture 5% (£2 billion) of this market.[2.29]

Land-based engineering

Land-based engineering employs 22,850 in the UK and is worth £4 billion a year.[2.30] It covers machinery used from farming to forestry to sports grounds. This ranges from tractors with satellite guidance and remote monitoring down to domestic lawn mowers and hedge trimmers.

In 2016, an estimated £1.5 billion worth of new farm machinery was sold in the UK.[2.31] The number of farming businesses in the UK has continued to consolidate towards fewer and larger businesses relying more on mechanisation and contractors. This leads to less but larger and more sophisticated agricultural machinery being sold.

Much of the agricultural engineering equipment sold in the UK is imported. Although the number of companies manufacturing in the UK has reduced, many export to elsewhere in the EU and globally. The global market for agricultural machinery is estimated to be roughly €100 billion. [2.32]

Automotive, aerospace, space and defence

Automotive industry

The UK automotive industry had a turnover of £77.5 billion in 2016 – a significant part of the £571.58 billion total manufacturing turnover in 2016 (**Figure 2.17**). The industry employed 169,000 in automotive manufacturing and 25,000 engineers in UK motorsport. In 2016, 1.72 million cars were built and 1.35 million vehicles were exported. UK car production reached the highest level in 17 years and 78,000 people were employed in the UK supply chain.[2.33]

Case study – Bioelectric medicine

Lucy Waterman, STEM careers manager (GSK)

We're all familiar with the life-saving impact of pacemakers and defibrillators on the heart. But we are now discovering the potential of the body's nervous system to treat diseases as diverse as asthma, diabetes, arthritis and high blood pressure. This has spawned a whole new field, called bioelectronic medicine.

GSK is leading research into this new scientific field. Innovation is fundamental to driving improvements in healthcare, and our researchers are pursuing the latest scientific avenues and technologies so we can continue to develop medical breakthroughs for patients.

Bioelectronic medicine involves the attachment of small, implantable devices to peripheral nerves that would modify the electrical signals from the brain to the organs in the body. We believe that recent scientific advances have made it possible to control specific sets of neurons, creating the potential for more precise bioelectronic medicines.

Bioelectronic medicine is a vision far from today's medical practice. But we believe that one day these devices could be used to treat a range of chronic diseases, with greater precision and fewer side effects than with conventional medicines. Our ambition is to deliver a marketable product in the next decade.

Right now, it may sound like science fiction, but we're edging closer to a future where precision electronic therapies sit alongside the medicines and vaccines we use today. It's like learning a new language – the electrical language of the body. Through learning to read and write the electrical signals that travel between the brain and the body's organs, we believe we can open up a whole new frontier in treating disease.

In 2017, there was a move away from diesel and petrol vehicles. According to the Society of Motor Manufacturers and Traders (SMMT), there were 83 different models of alternatively-fuelled cars and vans available in the UK in early 2017.[2.34] In 2017, under the UK government plans to improve air quality, the government announced a ban on new petrol or diesel-only vehicles from 2040. Volvo announced it will only sell hybrid or electric cars from 2020.[2.35] Jaguar Land Rover also announced that every new car launched from 2020 will be electrified.[2.36] In 2016, the UK automotive manufacturing industry invested over £2.75 billion in research and development.[2.37]

2.25 HM government. 'Medical technology in the UK', October 2017.
2.26 Deloitte. '2017 global life sciences outlook: Thriving in today's uncertain market', 2017.
2.27 HM Government. 'Industrial Strategy: Building a Britain fit for the future', 2017.
2.28 HM Government. 'Industrial Strategy: Life Sciences Sector Deal', 2017.
2.29 The Financial Times. 'UK's growing medical tech sector looks to be in rude health', March 2016.
2.30 LANTRA. 'Land-Based Engineering', 2017.
2.31 The Agricultural Engineers Association. 'Industry Facts', 2017.
2.32 Agricultural Engineering Association. 'The Agricultural Engineering Market – An Overview', 2017.
2.33 SMMT. 'SMMT Motor Industry Facts 2017', 2017.
2.34 SMMT. 'Carmakers come together to promote low emission vehicles, as motorists across UK call for greater incentives to switch and better charging infrastructure', February 2017.
2.35 BBC. 'New diesel and petrol vehicles to be banned from 2040 in UK', July 2017.
2.36 Jaguar Land Rover. 'Every Jaguar and Land Rover Launched From 2020 Will Be Electrified', September 2017.
2.37 SMMT. 'SMMT Motor Industry Facts 2017', 2017.

This move towards electric vehicles comes alongside increasing automation and connectivity. Examples of this automation are automated emergency braking, lane departure warning and adaptive cruise control. KPMG forecasts that such technology will add 1% to GDP and create 25,000 jobs in automotive manufacturing by 2030. [2.38]

Aerospace

The UK's aerospace industry is the largest in Europe and second globally to the USA.[2.39] Aerospace employed 120,000 people and supported a further 118,000 jobs in 2016 in the UK. The industry represents £27.7 billion in exports, and has increased its turnover since 2011 by 39%, reaching £31.8 billion in 2016. According to a 2017 survey by ADS, the trade body for aerospace, defence security and space, 26% of employees in UK aerospace companies were in research, design and engineering (approximately 31,000). [2.40]

The Made Smarter Review, a 2017 industry-led review into UK manufacturing opportunities for industry digitalisation technologies, found aerospace offered the greatest potential with industrial digital technologies, for cost reduction and new business models. This could be worth £17.5 billion over the next ten years.[2.41]

Thus, the conclusion of a 2016 study by BIS that the UK aerospace industry has not kept pace with global aerospace growth poses some concern for the sector. Among its findings was the shortage of manufacturing and advanced technology skills, such as composite manufacturing – which could save weight and therefore costs – and data security in the aerospace industry. [2.42, 2.43] Moreover, just over a third (34%) of the aerospace companies surveyed by ADS said they were not confident in accessing the design and engineering skills they need.

With a turnover of £31.8 billion, the UK's aerospace industry is the world's second largest. The Made Smarter Review noted that if it embraced industrial digitalisation, it could grow by another £17.5 billion in the next ten years. However, over a third of aerospace companies surveyed said they were not confident in accessing the design and engineering skills they needed.

Space industry

The UK space industry made up 6.5% of the global space industry and contributed £5.1 billion in gross value added (GVA) to the UK economy in the 2014 to 2015 financial year. It employed 38,522 people. Positioning, navigation and timing, metrological, earth observation and telecommunication satellite services are estimated to support 13.8% of GDP.[2.44] The 2017 Space Industry Bill includes measures to provide spaceports for commercial space flights from the UK.[2.45]

Defence industry

While the UK is the second largest defence exporter, there are also major defence equipment programmes in the UK.[2.46] These include the Queen Elizabeth carrier programme,[2.47] a new fleet of armoured vehicles,[2.48] and a new fleet of maritime patrol aircraft.[2.49]

The defence industry employed 142,000 people in 2016, including 4,300 apprentices. Turnover grew by 10% from 2010 to £23 billion and contributed £8.7 billion GVA to the UK economy. According to the 2017 Defence Industry Survey, 21% of defence company employees were in research, design and engineering, accounting for some 30,000 jobs. Notably, of the companies surveyed, 42% planned to invest in design and engineering, and a third expressed concerns about accessing crucial research and development or design and engineering skills.[2.50]

Construction and infrastructure rail and roads

Construction had a turnover in 2016 of £171.91 billion (**Figure 2.17**), representing 14.0% of total turnover produced within the engineering sectoral footprint (**Figure 2.16**).

Although activity in construction has declined in commercial work, increases in house building alongside infrastructure projects has led to an overall marginal increase in 2017. [2.51, 2.52] It is expected that this trend will continue. According to forecasts by the CITB's Construction Skills Network, average construction output will grow slightly by 1.7% per year between 2017 and 2021. Much of this is attributed to a 5.4% increase in infrastructure output, which will account for nearly half (45%) of all construction growth. The CITB furthermore forecasts that the annual recruitment requirement for civil engineers will increase from 53,630 in 2017 to 57,610 in 2021.[2.53]

The 2017 Made Smarter Review likewise estimated that between 2017 and 2017, the value of the construction industry will increase by 8% as a result of industrial digitalisation technologies. This is in part due to the cost reduction that will be enabled through the use of new technologies. For example, monitoring of assets by connected smart sensors or use of drone mounted scanners at project sites can inform decisions to mitigate risk early on in the design process.[2.54]

2.38 KPMG. 'Connected and Autonomous Vehicles – The UK Economic Opportunity', March 2015.
2.39 ADS. 'Industry facts & figures 2017', 2017.
2.40 ADS. 'UK Aerospace Outlook 2017', June 2016.
2.41 'Made Smarter Review.' October 2017.
2.42 BIS. 'UK Aerospace Supply Chain Study', July 2016.
2.43 BBC. 'Carbon fibre planes: Lighter and stronger by design', January 2014.
2.44 UK Space Agency. 'Summary Report: The Size & Health of the UK Space Industry', December 2016.
2.45 UK Parliament. 'Space Industry Bill [HL] 2017-19', 2017.
2.46 UK Defence Journal. 'UK is second largest global arms dealer', September 2017.
2.47 Royal Navy. 'Queen Elizabeth Carriers', 2017.
2.48 MoD. 'Ministers announce Ajax delivery milestone in Wales', September 2017.
2.49 RAF. 'Defence secretary announces new maritime patrol aircraft squadrons', July 2017.
2.50 ADS. 'UK Defence Outlook 2017', September 2017.
2.51 IHS Markit, CIPS. 'UK Construction Purchasing Managers' Index, September 2017; Construction Products Association. 'Construction Industry Forecasts 2017-2019', April 2017.
2.52 Construction Products Association. 'Construction Industry Forecasts 2017-2019', April 2017.
2.53 CITB. 'Construction: growing to meet the infrastructure challenge', 2017.
2.54 'Made Smarter Review.' October 2017; BSI. 'BIM level 2', 2016.

Building information modelling

Building information modelling (BIM) is a project management approach that uses digital information to design, construct or operate a building or infrastructure asset.[2.55] It is increasingly common in construction and infrastructure.[2.56] BIM standards necessarily raise the requirement for digital skills – especially since the UK government made the new BIM level 2 standards mandatory for public projects in 2016. Whereas BIM level 0 is the use of 2D CAD drawings, BIM level 2 involves the creation and use of 3D models where points or objects in the model are associated with additional data or information. The model is then shared with all parties who collaborate on the project.[2.57]

Smart meters

The trend toward increasing digitisation is also apparent with the rise of smart infrastructure. For example, smart energy meters for electricity and gas are increasingly common. These send digital readings of energy consumption to the energy supplier and allow the bill payer to more easily monitor their energy usage.[2.58] However, although relatively simple in concept, implementation of this to date has proven not to be a smooth process.[2.59]

Digital railways and smart motorways

In 2015/16, UK rail passengers made 1.7 billion journeys, covering 67.4 million km. Approximately 8% of distance travelled in Great Britain in 2015 was by rail (83% by cars, vans and taxis). Of all public transport trips during 2015 to 2016, national rail accounted for 20% of passenger journeys, and 61% of passenger km.

Rail journeys have doubled in the last 20 years, with the number of rail journeys in the United Kingdom the second highest in the European Union in 2014. The majority of growth has been in London and the South East, with 64% of journeys either starting or ending in London. In 2015 to 2016, Government support to the rail industry was £4.8 billion. Passenger revenue generated another £9.3 billion.[2.60]

Figures from 2013 estimate the economic contribution of the industry and its supply chain was the employment of approximately 212,000 people, the generation of £9.3bn in GVA each year, and the provision of £3.9bn of tax revenue to the Exchequer. Importantly, the tax contribution almost exactly offset the funding provided by government to the industry. It was also responsible for up to £10bn worth of additional productivity in the economy, through the impact of the rail industry on other industries in the economy.[2.61]

The digital railway programme aims to increase rail capacity without building additional track. This is a change from signalling based on fixed blocks of track, to block signalling sited within moving trains. The result is that trains can be run closer together, increasing the capacity of the network.[2.62] This is a critical part of Network Rail's railway upgrade plan, the largest modernisation programme since the Victorian era. The programme includes High Speed 2 and Crossrail (discussed later this chapter), as well as electrification and station upgrades.[2.63] This makes Network Rail, in its own words, "one of Britain's largest engineering companies" working on "some of the most visionary and challenging engineering projects in Europe" beyond normal operation and maintenance tasks.[2.64] Unsurprisingly, these major projects increase demand for engineers. For example, it is anticipated that an additional 7,200 engineering and technical workers will be needed in high speed rail by 2020.[2.65]

Smart motorways are another example of the march of digitisation. Here, technology is used to change speed limits to smooth traffic flow, use the hard shoulder as an additional lane, or to close lanes for emergency vehicle access. Smart motorways increase capacity more cheaply than traditional road widening schemes.[2.66]

These types of projects and their stage of construction have a significant effect on the types and volumes of engineering skills in demand. For example, CITB estimates that in 2021, the Hinkley Point C nuclear reactor construction project will account for 0.8% of total UK construction output.[2.67]

Energy and water

Carbon emissions in the UK have fallen and national income risen faster and further per person than any other nation in the G7. Since 1990, emissions are down by 42% while the economy has grown by 67% and the UK achieved a decarbonisation rate of 7.7%, almost three times the global average in 2016.[2.68]

The UK appears to be reaching a tipping point in relation to renewable energy, with Duncan Burt, the director of National Grid noting that, "We've gone from renewables being a part of the mix to often being a significant, majority part of the mix." [2.69] In early June 2017, solar, wind, biomass and hydro technologies produced the majority of Britain's electricity supply (54.4%) for the first time ever, while nuclear technology produced a further 23.2%.[2.70] Onshore and offshore wind and solar have consistently produced over 10% of the electricity generation mix since Q4 2015. [2.71] The renewable energy industry is a sizeable employer, employing nearly 126,000 people in 2016. [2.72]

2.55 BSI. 'BIM level 2', 2016.
2.56 ICE. 'BIM in infrastructure, Not just a fad', 2017.
2.57 NBS. 'BIM levels explained', November 2014.
2.58 Uswitch. 'Smart meters explained,' 2015.
2.59 IET. 'Smart meters: what would it take to stop the national rollout juggernaut,' May 2017.
2.60 DfT. 'Rail Trends Factsheet', 2017.
2.61 Oxera. 'What is the contribution of rail to the UK economy?', July 2014.
2.62 Network Rail. 'Digital Railway', 2017.
2.63 Network Rail. 'Our Railway Upgrade Plan', 2017.
2.64 Network Rail. 'Careers: Engineering', 2017.
2.65 ICE. 'Mind the gap: The need for rail engineering skills', December 2015.
2.66 Highways England. 'Smart motorways programme', 2017.
2.67 Construction Skills Network. 'Forecasts 2017-2021', 2017.
2.68 PWC. 'The Low Carbon Economy Index 2017', 2017.
2.69 The Guardian. 'This summer was greenest ever for energy, says National Grid', September 2017.
2.70 The Telegraph. 'UK sets new renewable energy record as wind and solar surge', June 2017.
2.71 Ofgem. 'Electricity generation by quarter and fuel source (GB)', July 2017.
2.72 Renewable Energy Association. 'REView 2017', September 2017.

Oil and gas

In 2016, capital investment in the UK offshore oil and gas industry was £8.3 billion with the industry spending £7 billion operating these assets.[2.73] UK offshore oil and gas has been declining from its peak but still employed 28,300 people and supported an additional 273,900 jobs in 2017.

Decommissioning is seen as an emerging market, with an expected spend of £17.6 billion between 2016 and 2025.[2.74] In fact, in 2016 decommissioning was the only area of increasing spend within the oil and gas industry, reaching 7% of the total industry's spend at £1.2 billion.[2.75] Nevertheless, oil and gas will still provide two-thirds of total primary energy by 2035 according to the Department for Business, Energy & Industrial Strategy (BEIS). It is estimated that there could be up to 20 billion barrels of oil and gas still to recover from the UK's offshore areas.[2.76] Exploration and development of onshore gas oil and gas, particularly shale gas, continues – although opposition to 'fracking' has slowed progress. [2.77]

In addition to oil and gas, the following sections look more closely at wind, solar and nuclear energy, along with energy storage. However, there are other renewable sources worthy of note. For example, the potential of tidal power was reported in **Chapter 1** of Engineering UK 2017: the state of engineering. Biomass is another example, with the Scottish government allocating £1.8 million for the UK's first deep geothermal district heating system in Kilmarnock, western Scotland. [2.78]

Offshore and onshore wind

The offshore wind industry has grown particularly dramatically, with the UK now one of the leading countries in this area.[2.79] In 2011 to 2012, turnover was £2.10 billion. By 2015 to 2016, turnover had increased to £3.19 billion. Over the same period, the number of people employed across the UK supply chain increased from 16,200 to 21,557.[2.80] Onshore wind has similarly increased from a turnover of £2.11 billion in 2011 to 2012, to £2.97 billion in 2015 to 2016. It supported 20,209 jobs across the supply chain in 2015 to 2016.

This growth is being driven by advances in technology and coverage. Offshore turbines have increased in capacity per turbine from 3.7MW in 2007 to 8MW in 2017. The UK government aims to increase off shore wind generation capacity from 5.7GW to 10GW by 2020.[2.81]

One effect of this growth is that offshore wind is forecast to generate electricity more cheaply than nuclear energy by 2022.[2.82]

Solar energy

The solar (photovoltaic) industry had a turnover of £2.04 billion in 2015 to 2016 and employed 13,687 people across the supply chain. After changes in subsidies, the UK solar industry contracted in 2016 but still produced over 10,000GWh in 2016. [2.83]

Energy storage

Energy storage is another emerging industry. A key feature of solar and wind is their variable electricity output, depending on how much wind and sunlight there is moment by moment. The growth in these technologies has made balancing load on the national grid a bigger issue. In turn, this has increased the focus on energy storage technologies [2.84] such as batteries and pumped hydro (an example of which we give later in this chapter).

Nuclear energy

Nuclear power supplies around 11% of the world's electricity, with an average of around 20% in the UK. There are currently over 437 commercial nuclear power stations operating in 30 countries and an additional 67 are under construction. In the UK, there currently are 16 nuclear reactors and all but one of these will be retired by the late 2020s. The spent fuel from the current generation of nuclear reactors is recycled for re-use.

The UK nuclear industry currently employs over 60,000 people involved in a range of activities from power generation to clean-up and construction. This is likely to increase in the years to come as UK Government policy is to support the building of new nuclear power stations in the UK. The first of these, Hinkley Point in Somerset, is expected to be online by 2024 and will have two reactors on site. A further nine or ten reactors are planned to be built across another four sites, giving a total of 16GW of new nuclear electricity production by 2030. The investment to build these power stations is coming from private utilities and is estimated at more than £70 billion.[2.86] Hinkley Point is expected to provide up to 25,000 jobs during the lifetime of the project and once built will provide about 900 full-time jobs. The 2017 Nuclear Workforce Assessment, a forecast of supply and demand for skills until 2021, forecasts an increase in total workforce required, across the industry, from 87,560 in 2017 to 100,619 in 2021.

Water

In 2016, water supply, sewerage, waste management and remediation had a turnover of £24.52 billion (**Figure 2.17**): 2.0% of turnover generated by engineering enterprises (**Figure 2.16**). The water industry faces a number of challenges, beyond regulatory and commercial pressures. Increased frequency of droughts and floods have immediate effects on water supply and wastewater treatment. Ageing infrastructure and population growth are also affecting demand and capacity. A key priority in the water industry is therefore improving resilience.[2.87] Engineers are needed to make this happen, from building and commissioning new treatment plants to large scale projects like the Thames tideway sewer.[2.88]

2.73 Oil & Gas UK. 'Key Facts', 2017.
2.74 Oil & Gas UK. 'Decommissioning Insight 2016', 2016.
2.75 Oil & Gas UK. 'Economic Report 2017', 2017.
2.76 Oil & Gas UK. 'Key Facts', 2017.
2.77 WIRED UK. 'What is fracking and why should you care? WIRED explains', June 2017; The Guardian. 'This summer was greenest ever for energy, says National Grid', September 2017
2.78 Arup. 'Scotland's first deep geothermal district heating network given backing', September 2017.
2.79 The Telegraph. 'Britain's wind turbines catch breeze of a rising industry', May 2017.
2.80 Renewable Energy Association. 'REView 2017', September 2017.
2.81 The Telegraph. 'Britain's wind turbines catch breeze of a rising industry', May 2017.
2.82 BBC. 'Offshore wind power cheaper than new nuclear', September 2017.
2.83 Renewable Energy Association. 'REView 2017', September 2017.
2.84 National Grid. 'Enhanced Frequency Control Capability', 2017.
2.85 The Nuclear Institute. 'The UK nuclear industry: How it works an d how you can be a part of it…', 2017.
2.86 National Skills Academy for Nuclear. '2017 Nuclear Workforce Assessment launched', July 2017.
2.87 Water UK. 'Improving resilience', 2017.
2.88 Tideway. 'The tunnel, September' 2017.

Another element of improving resilience is energy use. Pumping water, treating it for supply, and wastewater processes are energy intensive. Increased use of renewable energy sources, in the water industry, is intended to reduce the significant volumes of greenhouse gas emissions.[2.89] This in turn will create more demand for renewables and the engineering skills they need.

Manufacturing

In 2017, manufacturing accounted for 45% of UK exports,[2.90] making the UK the 8th largest manufacturing country by exports in the world. Almost half (46.5%) of turnover generated by engineering enterprises came from manufacturing in 2016 (**Figure 2.16**), although there is still evidence of skill shortages. The MHA association of regional accountancy firms, in collaboration with the Institution of Mechanical Engineers, surveyed 464 mostly small to medium manufacturing companies across the UK in 2017. They reported higher shortages than in the previous two years: 46% reported difficulties in recruiting skilled machinists or technicians; 39% had difficulty recruiting experienced engineers with specific skills; and only a quarter reported no problems in recruiting staff. Notably, where recruitment was an issue, 18% were looking to adopt lean manufacturing and 16% were turning to automation to compensate. For some manufacturing companies energy sourcing was a consideration, with 15% investing in energy efficient plants, 7% planning to use renewable energy, and 9% reporting having already transitioned. [2.91] As with the water industry, this will create more demand for renewables and the engineering skills they need.

Case study – Industrial digitisation

Ann Watson, Chief Executive, Semta

The history of industrial progress has been a transition to new labour saving manufacturing processes and a raft of innovations and inventions that have changed people's lives for the better. As it was in industrial revolutions 1 (steam), 2 (electricity) and 3 (computers), so it will be with the fourth industrial revolution.

For advanced manufacturing and engineering, the shift towards integrated digital ways of working will likely mean a shift away from the rigid demarcation of engineering disciplines we have today. Engineers of the future will not need the same skillset as their predecessors have today. Instead, they will need to be creative, adaptable and, crucially, ready to take on new skills and work on new projects.

Smart engineering firms are already embracing the future and shaping their training today to meet future need. So Rolls-Royce, for example, is now training its engineers to be less specialised and more adaptable, as the walls separating job roles are broken down by technology. Dyson has just opened a university that will train engineers who can work in any discipline.

Industrial digitalisation doesn't have to mean job losses. Yes, jobs and industries were lost to previous industrial revolutions. But the upsides of those revolutions were the invention of new industries and the creation of many more jobs.

Remember: the net effect of each of the 3 previous industrial revolutions has been the creation of better work for humans, if humans are adaptable and willing to shift to new ways of working (and thinking). So let's get on with the job of creating an engineering workforce that is truly ready for our digital future.

Industry 4.0

A growing trend in manufacturing is the use of technology to promote collaboration and information sharing between companies. Dubbed 'Industry 4.0' and sometimes referred to as the industrial 'internet of things' or the fourth industrial revolution, this development has been on policy agendas for some time. For example, it was one of the topics at the January 2016 World Economic Forum annual meeting in Davos. [2.92]

Industry 4.0 builds on the automation of single machines or processes (Industry 3.0) to create end to end digitisation of all physical assets.[2.93] In simpler terms, business advice firm BDO defines it as follows:

"It essentially means smart, flexible factories, where machines capture more data and convey more useful data to business operators so that they can make quicker, better decisions about how something is manufactured." [2.94]

The 2017 Made Smarter Review estimated that the use of technology to promote collaboration and information sharing – often dubbed as Industry 4.0 or the 'internet of things – could increase the value of UK manufacturing by as much as 14%.

2.89 Water UK. 'Improving resilience', 2017
2.90 EEF. 'UK Manufacturing 2017/18, the facts', September 2017.
2.91 MHA. 'Manufacturing and Engineering: Annual report 2017/18', September 2017.
2.92 WEF. 'World Economic Forum Annual Meeting 2016', 2016.
2.93 PwC. 'What we mean by Industry 4.0', 2017.
2.94 Page 2, BDO. 'Industry 4.0 Report', June 2016.

While the realisation of Industry 4.0 is still some way off, the connected factory is becoming more widespread. The drive appears to be to increase revenue rather than cut costs.[2.95] Over half of the manufacturers surveyed in 2016 were using connected sensors or connected alarms. About a third were monitoring motors or actuators and slightly under a third were using robots. Of the manufacturers surveyed, 80% expected improved factory connectivity to increase output levels and 68% expected it to improve quality. A lower, but still significant, proportion expected to increase production flexibility (44%) and reduce production cycle time (44%). Only a quarter (24%) expected increased connectivity to reduce their staff costs.[2.96] The 2017 Made Smarter Review found digital transformation for industry 4.0 could increase the value of UK manufacturing by 10 to 14 percent. In the food and drink industry, costs could be saved through automation of labour and increased resource efficiency.[2.97]

Some public figures have voiced concerns about the social impact of automation displacing large numbers of workers. Ralph Speth, CEO of Jaguar Land Rover, for example, has highlighted the impact on UK truck drivers.[2.98] Yet increased automation may enhance rather than replace workers, with evidence of this already occurring in manufacturing. For example, the use of 'cobots' – robots working alongside humans – is being trialled by automotive companies. There is some evidence that this combination is more flexible, and therefore more productive, than large industrial robots working alone.[2.99]

Enterprise resource planning

Another trend in manufacturing is investment in ICT. A survey carried out by The Manufacturer found that 71% of manufacturers surveyed had invested more in ICT in 2016 than the previous year. Enterprise resource planning (ERP) was the most common technology investment for manufacturers, both in 2015 to 2016 and planned for in the following year.[2.100] ERP provides a similar function to BIM level 2, sharing common processes and data within an enterprise. This can improve collaboration between teams and increase efficiency.[2.101]

Additive manufacturing: '3D printing'

Finally, additive manufacturing (commonly referred to as 3D printing) uses a range of techniques to create 3D objects layer by layer, typically using polymers, metals or ceramics.[2.102] Additive manufacturing has become an important technology in high value manufacturing. This is a growing area and the UK has been a leading country in its development and commercial application.[2.103] It is estimated that the UK could take £5 billion of the £69 billion global market in 2025. This also requires more people skilled in this industry. It is estimated that between 13,000 and 45,000 members of the Institution of Mechanical Engineers alone need some form of additive manufacturing training.[2.104]

Additive manufacturing, which to date has primarily been used for model making and rapid prototyping, is now being used to make end-user parts.[2.105] For example, a 'printed' titanium bracket is being used on production A350 XWB Airbus aircraft.[2.106]

Technology

The broad trends towards increased automation and increased connectivity mean that all of the engineering-related sectors have a technology theme running through them. In 2016, information and communication had a turnover of £198.02 billion (**Figure 2.17**), 16.1% of the engineering footprint turnover (**Figure 2.16**).

Big data

We highlighted big data as an area of opportunity in the 2016 and 2017 EngineeringUK reports. The big data industry continues to grow. The Centre for Economics and Business Research estimates that big data analytics will add £241 billion to the UK economy from 2015 to 2020, with the manufacturing industry expected to benefit the most (£57 billion). Adoption of big data analytics and 'Internet of Things' devices are also expected to create an additional 41,000 new jobs between 2017 and 2020.[2.107] To realise this potential, however, more data analysts, data infrastructure engineers and solution architects are needed.[2.108]

Industry experts define 'big data' with reference to volume (that is, how new technologies have increased capacity and hence datasets), velocity (often the need for near-real time transactions), variety (different types of formats). This means traditional methods of data management and analysis are not sufficient for these large and complex datasets.[2.109]

2.95 BDO. 'Industry 4.0 Report', June 2016.
2.96 The Manufacturer. 'Annual Manufacturing Report 2017', 2017.
2.97 'Made Smarter Review.' October 2017.
2.98 Jaguar Land Rover. 'Every Jaguar and Land Rover Launched From 2020 Will Be Electrified', September 2017.
2.99 Hitachi. 'Cobots: coming to a work place near you', February 2017.
2.100 The Manufacturer. 'Annual Manufacturing Report 2017', 2017.
2.101 Oracle. 'What is ERP?' 2017.
2.102 Loughborough University. 'About Additive Manufacturing', 2016.
2.103 Innovate UK. 'Mapping UK Research and Innovation in Additive Manufacturing', February 2016.
2.104 UK Additive Manufacturing Steering Group. 'Additive Manufacturing UK', September 2016.
2.105 Innovate UK. 'Mapping UK Research and Innovation in Additive Manufacturing', February 2016.
2.106 Amazing additivemanufacturing.com. 'Arconic and Airbus Achieve 3D Printing First', 2017.
2.107 Cebr. 'The Value of Big Data and the Internet of Things to the UK Economy', February 2016.
2.108 techUK. 'The UK's Big Data Future: Mind the Gap', October 2016.
2.109 Doug Laney. '3D Data Management: Controlling Data Volume, Velocity, and Variety', February 2001.

Case study – Developing autonomous ships

Paul Broadhead, Head of Community Investment & Education Outreach, Rolls-Royce

As disruptive as the smartphone, the autonomous ship looks set to revolutionise parts of the maritime industry – provided, that is, a number of technological and legal challenges can be overcome.

Rolls-Royce is leading the development of a range of technologies to enable remote and autonomous shipping, and this exciting opportunity is shaping the strategic direction for the company's marine business.

One research programme the company is leading is the Advanced Autonomous Waterborne Applications Initiative (AAWA). In collaboration with some of Finland's top research universities and other world-leading maritime companies, we are looking at the feasibility of remote controlled vessels.

Three key areas are being developed:

- Sensor fusion and object detection: On a ship, sensors are used for sensing the surroundings and monitoring equipment to create an understanding of both the internal and external environment of the ship for a shore-based crew.
- Control algorithms: These interpret the sensor data for functions such as reactive control for collision avoidance. For a vessel to produce a sufficiently accurate output for human interpretation, a range of sensor outputs need to be combined, which will require sensor fusion.
- Communication and connectivity: Each vessel in the future will still need human input, making it crucial that connectivity between the ship and the crew is bi-directional, accurate and supported by multiple redundant methods.

AAWA's research to date has highlighted how remote and autonomous ships could change the economic landscape. Macroeconomic changes might be significant and they will potentially redefine the roles of different players in the shipping business.

The 2010 to 2015 Coalition government identified it as one of the 'eight great technologies'[2.110] and worldwide revenues from the business analytics software associated with big data is predicted to grow from an estimated $150.8 billion in 2017 to more than $210 billion in 2020.[2.111]

A practical example of applying big data is in improving industrial safety. This application is already used in the oil and nuclear industries, and can also be applied to rail. One tool in development – the Red Aspects Approaches to Signals (RAATS) – analyses incidents where railways signals are approached when still on red and finds common factors between these incidents. In time, this tool might be integrated with on-train monitoring and data on signal condition and maintenance.[2.112]

Cyber security

The rise of the internet of things, both for consumer products and industry infrastructure and assets, means that cyber security is increasingly important. The House of Commons Public Accounts Committee has rated cyber-attacks as one of 4 top tier threats to UK security.[2.113] The engineering sectors are naturally involved with much of the UK's critical national infrastructure, with cyber security being just one security consideration. The water industry, for example, has now established principles for cyber security.[2.114] More broadly, organisations vulnerable to hacking and data theft are increasingly realising the need for cyber security experts, including cyber security engineers. PwC estimates that the European cyber security market is worth $22 billion and forecasts that it will increase to $25.3 billion by 2018.[2.115]

Artificial intelligence

Artificial intelligence (AI) is another area of technology likely to impact on future skills needs. Professional services company Accenture forecasts that AI could increase UK labour productivity by 25% by 2035. As with robotics, there are fears that AI could replace humans, but it may also create new jobs.[2.116] There is also the possibility that it will make new goods and services possible. For example, IPSoft has developed an AI platform that interacts naturally with humans, called Amelia. Amelia has been used as a virtual service desk agent but has also been piloted to support field engineers. Having 'read' the detailed manuals, Amelia can diagnose problems and suggest solutions.[2.117]

2.110 BIS and David Willetts, 'The 'eight great technologies' which will propel the UK to future growth receive a finding boost' (speech), January 2013.
2.111 International Data Corporation. 'Big Data and Business Analytics Revenues Forecast to Reach $150.8 Billion This Year, Led by Banking and Manufacturing Investments, According to IDC', March 2017.
2.112 Rail Engineer. 'Big data: a new approach to risk analysis and safety management', September 2017.
2.113 The Guardian. 'Skills shortage 'harming UK's ability to protect itself from cyber-attacks', February 2017.
2.114 Water UK. 'Cyber security principles for the water industry', March 2017.
2.115 PwC. 'Cyber security: European emerging market leaders', January 2017.
2.116 PwC. 'The economic impact of artificial intelligence on the UK economy', June 2017.
2.117 Accenture. 'Why Artificial Intelligence is the Future of Growth', 2016.

2.7 – Major infrastructure projects

One of the more visible contributions of engineering to UK productivity is the construction of new national infrastructure. The World Economic Forum ranked the UK 11th in the world in terms of the overall quality of its infrastructure in 2017, behind Germany (10th), the USA (9th) and France (7th).[2.118] The formation in 2015 of the National Infrastructure Commission (NIC) to independently assess the UK's long-term infrastructure needs and make recommendations to government represents an important opportunity to ensure UK infrastructure is fit for purpose. The UK government has since announced ambitious infrastructure plans with around £600 billion public and private infrastructure investment between 2017 and 2027.[2.119]

In July 2016, the government major projects portfolio had 143 projects worth over £455 billion. These are categorised as: infrastructure and construction; government transformation and service delivery; ICT; or military capability.[2.120] The skills found in the engineering footprint are needed for projects in every category.

Infrastructure resilience to both natural hazards (such as changing weather patterns) and man-made pressures (such as a growing and aging population) is a key area for development. The UK Infrastructure Transitions Research Consortium, a collaboration of seven universities and over 50 partners from infrastructure policy and practice, are examining this issue in depth, and are working on the world's first national infrastructure system-of-systems modelling platform and database (NISMOD).[2.121]

Infrastructure project examples

The following examples, which span different industries and nations of the UK, are only a few of the major infrastructure projects underway and are intended to provide an indication of the sheer range of work taking place.

Beyond these, there are other notable infrastructure projects at various stages. For example, at the site of the new nuclear power station, Hinkley Point C, 1,600 construction workers were already on site in 2017.[2.122] There is also the Thames tideway, a 25km sewer to protect the tidal River Thames from pollution, due to begin in 2018.[2.123] Additionally, the Queen Elizabeth Carrier Programme for the Royal Navy includes a £100 million project to upgrade port infrastructure as well as the construction of two 65,000 tonne aircraft carriers.[2.124] A new national ship building strategy has also been announced to produce export-ready general purpose frigates,[2.125] partly in response to the Parker review.[2.126]

Case study – The economic impact of HS2

Kate Myers, Head of Skills, Employment & Education, HS2 Ltd

Once it is fully operational in 2033, HS2 will form the backbone of the UK's rail network. Eight of Britain's10 largest cities will be connected directly by high speed services. But HS2 is so much more than just a railway. It will be a catalyst for economic growth across Britain.

HS2 will increase rail capacity and provide faster, easier and more reliable travel between Britain's economic hubs to better connect industries and businesses and help bridge the north-south divide. By bringing new investment, employment and regeneration to towns and cities up and down the country, HS2 has the potential to support hundreds of thousands of jobs.

Local areas are already building HS2 into their growth plans. In Birmingham, £900 million has been set aside for development around the reincarnated Curzon Street station. Birmingham City Council's masterplan predicts the scheme will create 36,000 jobs and 4,000 new homes. To the east of the city, Solihull is planning for 77,500 jobs and another 4,000 new homes around the new Interchange station. In total, the West Midlands Combined Authority expects HS2 to add £14 billion to the region's economy. Just along the M42, the East Midlands has put together an HS2 Growth Strategy that plans for 74,000 new jobs and an extra £4 billion in GVA by 2042.

Alongside the 25,000 people who will be employed to design and build the new railway, these local figures – from just 3 of the 9 stations HS2 will build or redevelop – demonstrate the project's huge potential for jobs, growth and rebalancing the UK economy.

Crossrail railway line, London

One notable infrastructure project is Crossrail (the Elizabeth line), a high frequency, high capacity railway for London and the South East. Begun in 2009, the railway line is on track to fully open in 2019, under the control of Transport for London. Although it is Europe's largest construction project, at a cost of over £14 billion, Crossrail is seen as a way to generate productivity in the long-term. Already, it has supported 55,000 jobs (including over 600 apprenticeships) during its construction and awarded 62% of contracts to businesses outside London (95% of which were in the UK). After completion, it is expected to lead to 63,000 more jobs in the City of London[2.127] and Isle of Dogs and to increase UK GDP by £42 billion.[2.128]

2.118 Klaus Schwab. WEF. 'The Global Competitiveness Report 2017-2018', September 2017.
2.119 Infrastructure and Projects Authority. 'Transforming Infrastructure Performance', December 2017.
2.120 Infrastructure and Projects Authority. 'Annual Report on Major Projects 2016-17', July 2017.
2.121 UK Infrastructure Transitions Research Consortium. 'Homepage', 2018.
2.122 EDF Energy. 'Hinkley Point C: securing the UK's energy future', 2017.
2.123 Tideway. 'The Tunnel', 2017.
2.124 RN. 'HMS Queen Elizabeth makes debut in Portsmouth with first entry to her home port', August 2017.
2.125 MoD. 'Ambitious future for Naval Shipbuilding in the UK', 2017.
2.126 Parker, J. 'An Independent Report to inform the UK National Shipbuilding Strategy', 2016.
2.127 City of London Corporation. 'The Impact of Crossrail', April 2015.
2.128 Crossrail. 'Crossrail in numbers', 2016.

Western Link high voltage direct current, Scotland to Wales subsea cable

Another key infrastructure project is the Western Link high voltage direct current (HVDC). Despite delays, this is due for completion in 2018 at a cost of over £1 billion. This cable is expected to bring 2,200MW (enough for 2 million people) of renewable electricity from Hunterston in Ayrshire, Scotland, to Deeside in Wales and on to England: power that the national grid would otherwise have had no capacity to transmit.[2.129] The energy sector trade body estimated that the energy sector as a whole directly supported 137,000 jobs and indirectly supported another 500,000 in 2015.[2.130]

700MHz waveband use for mobile data

A third example is the clearance of the 700MHz waveband for mobile data use. (This waveband is currently used by digital terrestrial television and wireless communication at music, theatrical and sporting events.) Ofcom estimates this could lead to network cost savings of £900 million to £1.3 billion, improving services and lowering costs for mobile phone customers. The savings come from both a reduced need for mobile network base stations and improved performance in hard to serve locations as a result of enhanced signal. The subsequent freed-up waveband available can also make way for the development of new services and technologies.

These projects are large and complex, which is reflected in their risk rating status: many projects on the portfolio are rated amber rather than green.[2.131]

Queensferry crossing over the Forth, Scotland

Other major projects not listed on the government major projects portfolio include the Queensferry Crossing in Scotland, which opened in 2017, replacing the Forth road bridge. Since construction started in 2011, over 15,000 people have been inducted to work on the site.[2.132] At 1.7 miles, it is the longest structure of its type in the world and is estimated to have cost £1.45 billion. The bridge shields vehicles from high winds better than its predecessor and uses an intelligent transport system with variable speed limit signs and messaging boards to minimise congestion. It also has an internal dehumidification system to reduce corrosion and is intended to last for 120 years.[2.133]

The UK government has announced ambitious infrastructure plans with around £600 billion in public and private infrastructure investment over the next ten years.

Atlantic Gateway infrastructure programme, North West England

The Atlantic Gateway is another major infrastructure programme, spanning Liverpool to Manchester and estimated to cost £14 billion. It is expected to create of up to 250,000 jobs by 2030, with a GVA impact of £6 billion per year. It includes the development of:

- Sci-Tech Daresbury campus for science, business and research
- port facilities at Liverpool, Salford and Warrington
- the Mersey Gateway bridge, a six lane toll crossing[2.134]

Glyn Rhonwy pumped hydro energy storage project, Wales

Development consent was given in March 2017 for the Glyn Rhonwy pumped hydro project in Snowdonia, Wales.[2.135] This is an energy storage facility with a capacity of 99.9MW. The project will convert two abandoned slate quarries into lower and upper reservoirs. Water will be pumped into the upper reservoir when electricity is cheaper and released through a turbine to generate electricity. The project is expected to cost £160 million, and to recoup that cost in approximately 15 years. The carbon payback is estimated to be 6 to 9 months.[2.136]

Superfast Cymru superfast broadband, Wales

In 2012, the Welsh government also started Superfast Cymru, a next generation broadband project aiming to supply all businesses in Wales with access to next generation broadband by the middle of 2016 and to make sure all households are enabled by 2020.[2.137] By February 2015, 255 jobs had been created and 123 apprenticeships provided.[2.138] Between 2015 and 2016, superfast broadband coverage increased from 79% to 85% of the country and by the end of March 2016, 86.8% of business premises had superfast broadband.[2.139] At a cost of £231 million, the project was publicly funded, including £90 million from the European Regional Development Fund. However, it also received £26 million from BT, the contractor selected to deliver the project.[2.140] Although delayed, 650,000 business premises were due to be connected by June 2017. [2.141] The Wales Audit office reported in 2015 that the project was "delivering direct employment-related benefits".[2.142]

York Street Interchange upgrade Belfast, Northern Ireland

Meanwhile, in Northern Ireland, £400 million has been allocated to infrastructure projects between 2017 and 2018. This funding comes from the post-election confidence and supply agreement made in June 2017 between the Conservative Party and the Democratic Unionist Party.[2.143] Funded projects include upgrading the York Street Interchange in Belfast to address a bottleneck where 3 major roads link: the Westlink, the M2 and the M3 motorways. The scheme is forecast to cost between £130 million and £165 million and take 3 years to construct. It has an estimated benefit to cost ratio of 2.334.[2.144]

2.129 Western HVDC. 'Western Link Project', 2017.
2.130 Energy UK. 'Energy in the UK 2016', 2016.
2.131 Ofcom. 'Decision to make the 700 MHz band available for mobile data – statement', November 2014.
2.132 BBC. 'Queen to open new bridge across the Firth of Forth', August 2017.
2.133 Transport Scotland. 'Forth Replacement Crossing', 2017.
2.134 Atlantic Gateway. 'Business Plan', 2012.
2.135 BBC. 'Llanberis hydro power plant given go-ahead', March 2017.
2.136 Snowdonia Pumped Hydro. 'Project details', March 2017.
2.137 Welsh Assembly Government. 'Delivering a Digital Wales: The Welsh Assembly Government's Outline Framework for Action', December 2010.
2.138 Wales Audit Office. 'Welsh government investment in next generation broadband infrastructure', May 2015.
2.139 House of Commons Library. 'Superfast Broadband Coverage in the UK', March 2017.
2.140 Wales Audit Office. 'Welsh government investment in next generation broadband infrastructure', May 2015.
2.141 BBC. 'Superfast Cymru broadband scheme "failed to deliver", say AMs', November 2016.
2.142 Wales Audit Office. 'Welsh government investment in next generation broadband infrastructure', May 2015.
2.143 Conservative Party, DUP. 'UK Government Financial Support for Northern Ireland', 2017.
2.144 Department for Infrastructure. 'York Street Interchange', June 2017.

Engineering and the fourth industrial revolution

The world is waking up to the scale of change occurring in the labour market. Predictions abound regarding how these technological, socio-economic and geopolitical disruptions will continue to shape the future of work. The World Economic Forum has been focusing on this issue for some time, defining this period as the beginning of a fourth industrial revolution.

While technological change is nothing new, the accelerated pace and interconnectivity of current advances certainly is. Developments in genetics, artificial intelligence, robotics, nanotechnology, 3D printing and biotechnology, to name just a few, are all building on and amplifying one another. Alongside this technological revolution is a set of broader demographic, environmental and political drivers of change and it is the interactions between these developments that will generate new categories of jobs and occupations while partly or wholly displacing others. All this is laying the foundation for a revolution more comprehensive and all-encompassing than we have seen previously.

This process of rapid technological advance holds great promise but the patterns of consumption, production and employment being created also pose major challenges requiring proactive adaptation by corporations, governments and individuals. As whole industries adjust and new ones are born, many occupations will undergo a fundamental transformation. The skill sets required in both old and new occupations in most industries will change, transforming how and where people work and requiring an urgent and concerted effort for adjustment. Precisely how these developments are to shape our future will depend on how business, government and individuals react.

The skill sets required in both old and new occupations in most industries will change, transforming how and where people work and requiring an urgent and concerted effort for adjustment.

Susan Wilkinson,
Project Lead, Education, Gender and Work System Initiative, World Economic Forum,

Till Leopold,
Project Lead, Education, Gender and Work System Initiative, World Economic Forum

Robotics and machine learning are less likely to completely replace existing occupations than to substitute specific tasks to free workers up to focus on new tasks.

Much of the debate regarding technological transformations has been heavily polarised between those who foresee limitless new opportunities and those that foresee a significant dislocation of jobs. The Forum's *Future of Jobs report*,[2.125] which surveyed leading employers representing more than 13 million employees across 9 broad industry sectors in 15 major developed and emerging economies, together with our subsequent work on these issues, is an effort to become specific about the changes at hand. We have through consulting those well placed to observe the dynamics of workforces – chiefs of human resources, strategy officers, labour leaders and policymakers, together with those creating new models of work. Through this, we have been able to gather insights and knowledge regarding what the current shifts mean, specifically for employment, skills and recruitment across industries and geographies. We have also begun to assess how the benefits and burdens of the fourth industrial revolution will be distributed.

A key finding of The Future of Jobs report is that, in reality, the impact of the fourth industrial revolution is likely to be highly specific to the industry, region and occupation in question and the ability of various stakeholders to successfully manage change. Looking specifically at engineering, the future appears broadly positive. Our respondents expected strong employment growth across the architecture and engineering job family, with 3D printing, resource-efficient sustainable production and robotics all seen as strong drivers of employment growth. This is due to a continued and fast-growing need for skilled technicians and specialists to create and manage advanced and automated production systems. These shifts in production are expected to lead to a transformation of manufacturing into a highly sophisticated sector which requires highly-skilled engineers to make the industrial internet of things a reality.

Solid job growth is also expected for engineering roles in the consumer, information and communication technology and mobility industries. In addition, new job roles are being created and we received frequent mentions of emerging specialities. These include human resources and organisational development specialists, engineering specialities such as materials, bio-chemicals, nanotech and robotics, regulatory and government relations experts, geospatial information

339,000 extra jobs
are estimated to be created up to 2020 in the architecture and engineering job family globally.

Only one in four
companies envisage actively targeting female talent. This suggests that this strategy needs more focus.

systems specialists and commercial and industrial designers. By contrast, demand for additional engineering talent in its traditional core basic and infrastructure and energy industries is set to be fairly flat. In total then, an extra 339,000 jobs are estimated to be created up to 2020 in the architecture and engineering job family globally.

These new talent needs will put pressure on labour markets already struggling with skills gaps in such growth sectors. Given the overall disruption industries are experiencing, it is not surprising that, based on current trends, competition for talent in in-demand job families such as architecture and engineering is predicted to be fierce. By 2020, business expects that it will be significantly more difficult to recruit specialists across most occupations, but particularly for traditional middle-skilled and skilled trade roles. Finding efficient ways of securing a solid supply of talent is therefore a priority for virtually every industry.

This quest for talent will be made more complex given skills requirements will continue to shift throughout this period of change. The accelerating pace of technological, demographic and socio-economic disruptions is shortening the shelf-life of employees' existing skill sets, with business model changes often translating to skill set disruption almost simultaneously. But this need not be a negative trend. For example, technological disruptions such as robotics and machine learning are less likely to completely replace existing occupations and job categories than to substitute specific tasks previously carried out as part of these jobs. This has the capacity to free workers up to focus on new tasks and lead to rapidly changing core skill sets in these occupations.

The question, then, is how to meet these talent and skills challenges. Some of the most popular workforce strategies envisaged by companies include providing employees with wider exposure to roles across the firm; stepping up efforts to target the female talent pool; collaborating with the education sector more closely; and investing in reskilling current employees. However, a lack of understanding of disruptive changes and resource constraints are cited as the major barriers to managing change across all industries. This perhaps explains the mismatch between the magnitude of the upcoming changes and the relatively minor actions being taken by companies to address these challenges so far.

For businesses to capitalise on new opportunities, they will need to put talent development and future workforce strategy front and centre.

Another major measure lacking attention is addressing the wide gender gaps still present in particular occupations. Although recruitment of women into many specialist roles is expected to improve up to 2020, women still make up low numbers in the fast-growing STEM job families. The growth of new and emerging roles in computer, technology and engineering-related fields is outpacing the rate at which women are currently entering those types of jobs. This puts women at risk of missing out on tomorrow's best job opportunities and has the potential to aggravate hiring processes for companies due to a more restricted talent pool. Despite this, and even within the context of widespread proclamations in support of workplace gender parity, only one in four companies envisage actively targeting female talent. This suggests that this strategy needs more focus.

While the implications of accelerating disruptive change are far-reaching for employment and skills, rapid adjustment to the new reality and the opportunities it offers is possible, provided there is concerted effort by all stakeholders. For government, it will entail innovating within education and labour-related policymaking, requiring a skills evolution of its own. For the education and training sector, it will mean vast new opportunities as it provides new services to individuals, entrepreneurs, large corporations and the public sector. The sector may become a noteworthy new source of employment itself.

For businesses to capitalise on new opportunities, they will need to put talent development and future workforce strategy front and centre. Firms can no longer be passive consumers of ready-made human capital. They require a new mindset to meet their talent needs and to optimise social outcomes. This entails major changes in how business views and manages talent, both immediately and in the longer term.

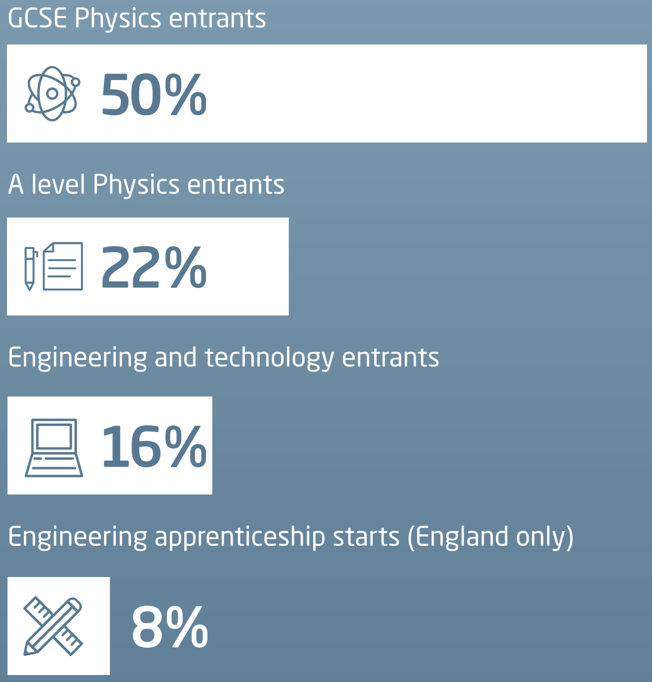
It is our actions today that will determine whether the wave of change brought by the fourth industrial revolution will result in a substantial displacement of workers or in the emergence of new opportunities. Without urgent and targeted action today to manage the near-term transition and build a workforce with futureproof skills, governments will have to cope with ever-growing unemployment and inequality, and businesses with a shrinking consumer base. The engineering sector, expected to undergo significant shifts and to be a major source of new and emerging job roles, therefore has a crucial role to play in helping to deliver on the positive potential of the future of work.

http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf

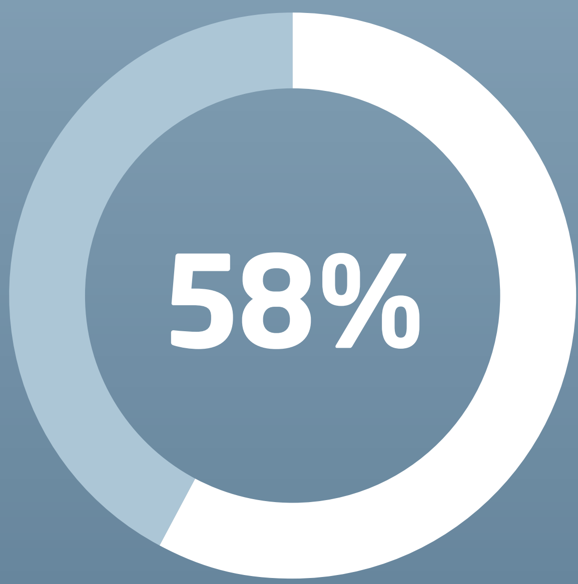
The engineering pipeline

Gender representation remains a key issue in the engineering pipeline.

Proportion female (%)



More needs to be done to raise understanding of apprenticeships.



of 11 to 14 year olds know almost nothing or just a little about what apprentices do and the different types of apprenticeships available

3 - Harnessing the talent pool

Careers education and guidance, STEM inspiration activity, and employer engagement can maximise momentum towards the pipeline during the secondary education stage

The first key leakage point in the engineering pipeline is when young people choose their GCSE subjects and enter key stage 4 of secondary school

Key points

The engineering skills pipeline

The largest flow of newly skilled talent into the engineering workforce comes directly from education. Between each educational stage there is potential for 'leakage' from the pipeline, as individuals make voluntary decisions about their progression. These 'leaks' impact strongly on the diversity of entrants into the workforce. It is crucial to encourage as many young people as possible into the pipeline at the start.

Population trends

Total population is set to grow by around 3% over the next 5 years and by over 11% in the next 20 years. In the next 5 years, studies project considerable increases in the number of 12 to 16 year olds (although the dip can still be seen in decreases in 18 to 21 year olds). Over the next 20 years, all age groups will grow, especially teenagers in secondary education. This is encouraging for the potential engineering talent pool.

Perceptions and attitudes toward engineering

Promisingly, the proportion of young people aged 11 to 19 who would consider a career in engineering has grown from 40% in 2013 to 51% in 2017. The challenge is to sustain their interest as they progress, and to convert that 'in principle' interest into more conscious desirability. Interest drops off as pupils grow older, and this decline is particularly pronounced for girls after the age of 14.

In addition, there is a clear need to strengthen knowledge of the profession. While young people tend to have a positive view of engineering – although not as positive as their view of science and technology – their knowledge of what the profession actually entails lags behind this positivity.

Nevertheless, there has been some progress in this area: in 2017, 27% of 11 to 14 year olds and 30% of 14 to 16 year olds reported knowing what people working in engineering do, compared with 15% and 18% in 2013. This could correlate with evidence of a rise in the proportion of young people reporting that they have taken part in a STEM activity. Around one third say they have done so within the last year.

Types of interventions

In England, careers provision is patchy and can miss those who need it most. A marketised landscape of external careers support has grown up to fill the gap, which schools struggle to access or differentiate. A new careers strategy for England was published in December 2017 and the centralised all-age strategies in Wales, Scotland and Northern Ireland are all hard-pressed. The Department for Education Careers Strategy makes clear that current provision is patchy and careers guidance has not been given the status it deserves.

A large number of players offer STEM-related enrichment or inspirational activities to schools and young people. There is evidence that such activities raise short-term interest in engineering careers, but a planned succession of interventions may be necessary to sustain positive attitudes. There is a need to coordinate the players in this market, to undertake more impact studies and to help schools select and access the most impactful interventions.

Current education policy emphasises that schools should engage with employers so that young people have encounters with people from the world of work. Historically, this involved hosting a week or two of work experience for a year 10 teenager but increasingly, they involve people from business or industry coming into school to give talks or facilitate enrichment. Spurred by government policy, a market in provision has sprung up, of which the STEM Ambassadors network is a part. Although talks in school by employers have been correlated with subsequent improved outcomes in work, these encounters are a form of inspiration that will work best when planned alongside generic careers support and other STEM enrichment experiences.

Diversity issues

The diminishing representation of girls and women with progression along the STEM skills pipeline is well known. Only 27% of girls' entries to A levels in 2017 are in STEM subjects. At first degree level, women comprise only 16% of engineering students. In the workforce, less than 1 in 10 professional engineers are female.

The key point of 'leakage' in the skills pipeline for those of minority ethnic background appears to occur at the transition to employment, rather than during subject choices. 25% of engineering students are of BME origin – a higher percentage than in the general population of the same age range – yet they only account for 8% of the engineering workforce.

Enrichment and employer-led activities need to take account of the persistent under-representation of women and ethnic minorities in engineering if they want to harness more of the potential talent in the skills pipeline.

3.1 – The engineering skills pipeline

The term 'pipeline' is used widely to describe the educational pathway that leads to an adult career in engineering or STEM fields. It is based on the idea that the supply of engineers depends on enough young people entering the pipeline in education and flowing through it until they emerge as qualified candidates. The metaphor is commonly used to highlight 'leaks' that occur at different stages and eventually affect the diversity of the STEM workforce: in particular, how these leaks vary with gender, ethnic or socio-economic background.

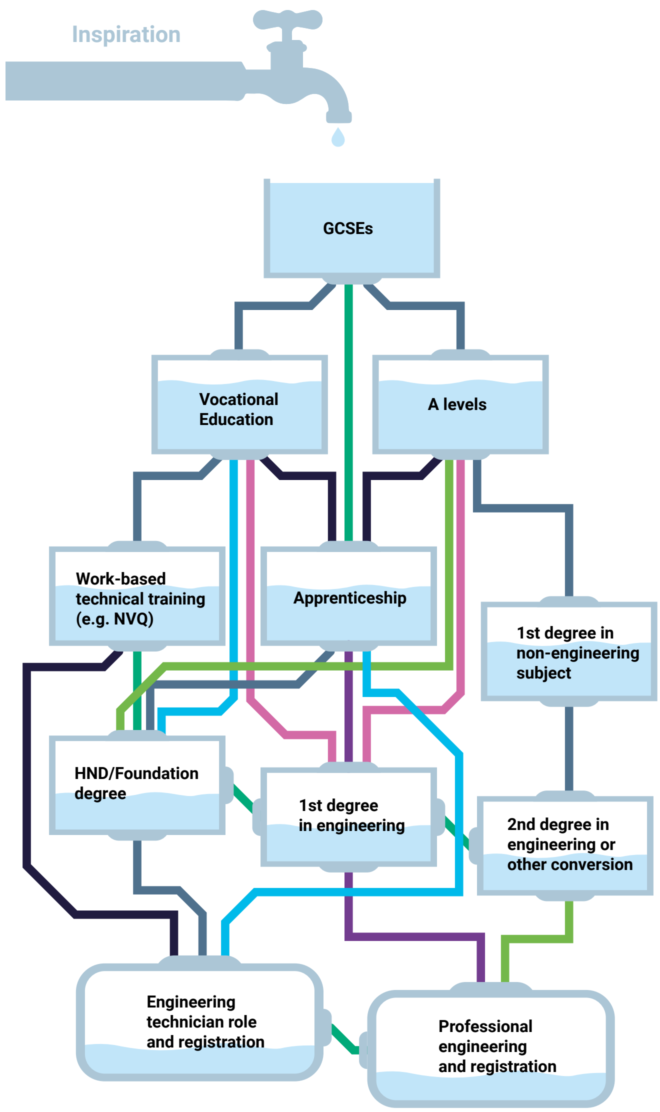
Some commentators have challenged this description, accusing it of being too linear and overly focused on the supply of skills. For instance, it doesn't account for deviations from the engineering pathway that some people inevitably make throughout their career.[3.1] The pipeline concept only assumes leakages and doesn't account for people entering the flow mid-way, for instance when they change educational direction or employment sector. Nonetheless, it is a valuable metaphor for the largest element in the supply of engineering skills. Practically, to increase the flow of engineering skills into the labour market, we need to maximise the number of people who progress right through the pipeline and minimise unnecessary leaks.

Professor John Perkins uses the pipeline analogy in his report for the Department for Business, Innovation and Skills (BIS) to depict the multiple routes along which developing talent flows towards professional registration (Figure 3.1).[3.2] He also highlights the many points at which talent leaks from the system. The levels in the tanks in the diagram are schematic, and intended to give an idea of the impact that the leakages have on the total flow.

The diagram's three main stages broadly map onto the next three chapters in this Engineering UK report, namely:

- compulsory education
- vocational education
- higher education

Figure 3.1 The pipeline for engineering skills leading to professional registration



Source: BIS, 2013

3.1 BIS. 'STEM graduates in non-STEM jobs', March 2011.
3.2 BIS. 'Professor John Perkins' Review of Engineering Skills', November 2013.

Compulsory education

Perkins usefully splits education into a general stage of academic foundation (broadly up to and including key stage 3) and later stages which result in formal qualifications such as GCSEs and A levels. The first stage involves all students, whereas in later stages students have made choices. For example, they may choose to study separate sciences or combined science at GCSE, and a variety of elective subjects outside the compulsory core of the curriculum. Subject choices post-16 (for A level or vocational qualifications) are largely open to the student, although it is now compulsory to remain in education or on a recognised training scheme until 18 years of age. Once choice is introduced, there is potential for leakage from the pipeline. This could be voluntary leakage, where a student deliberately chooses a subject that does not lead towards a STEM or engineering pathway. Or it could be involuntary, for example where a student fails to meet academic eligibility criteria for the next stage or attends a school where certain subjects are not offered. It is at these 'choice' points that other parties can have an influence on young people's decisions. At these times, the profile of young people in the pipeline begins to change, with certain types of students disproportionately likely to leak out: for example, a high proportion of female students choose not to study physics.

Vocational education

In this year's report, we have combined information about work-based training opportunities, such as apprenticeships and other vocational routes within further education (FE), in a single chapter. Many of these pathways can be entered at either age 16 or 18, and are either voluntarily chosen or relate to academic eligibility. Increasingly, the government refers to these routes as 'technical education'. These routes appear to be affecting the diversity of people emerging from the pipeline: for example, apprentices in engineering are overwhelmingly white and male.

Higher education

For some time, the government has promoted progression to higher education (HE) as the optimum path for any students that could meet the eligibility criteria (although this policy is now softening in favour of a greater balance of routes). There are several potential leakage points that relate to HE: choosing a subject for undergraduate study, choosing to carry on with or change subject during the HE programme and, for some, choosing to go on to postgraduate study. At each of these stages, the diversity of the student profile changes. Many students also decide on their ultimate career direction while still in HE.

This chapter focuses on opportunities to influence the flow of young people as they move through compulsory, vocational and higher education. We also examine what is known about the impact of such approaches.

The first key leakage point is when young people choose their GCSE subjects and enter key stage 4 of secondary school.

3.2 – The importance of engaging young people

At each stage in the pipeline and into employment, young people make conscious and voluntary decisions about where they are going and how they will get there. If the engineering sector acts on opportunities to influence these decisions, it could positively affect the flow of young people into the pipeline. This chapter focuses on the early stages of this opportunity. Without substantial momentum early on, the potential flow in all subsequent stages will be diluted. For example, it may be too late to start to excite learners about careers in engineering when they're 16, as they already have made chosen subjects that will restrict their subsequent options. And once they're out of the pipeline, they may not have ready opportunities to re-enter it later on.

The first key leakage point is when young people choose their GCSE subjects and enter key stage 4 of secondary school. Although study of mathematics and science is compulsory, many will be able to choose whether to study separate sciences or combined science. This should not have an impact on their options post-16, but will affect the extent of their learning that is based on STEM subjects. Some pupils may have the opportunity to select other STEM-related subjects, such as design and technology, computing or even engineering itself. At age 14, some young people also have an opportunity to change type of school. For example, they might go to a university technical college (UTC) and specialise in engineering-focused subjects, although only a minority currently take this pathway.

It is because this stage is so important that EngineeringUK actively promotes the benefits of studying STEM subjects to young people in key stage 3, when they are aged 11 to 14 years. However, as Perkins points out, there is also potential value in 'priming' the pipeline by inspiring young people about engineering, which is not covered in the key stage 3 science curriculum, and encouraging them to develop a strong academic foundation in STEM subjects, before they face subject choices. The aim is to encourage as many young people as possible to make a conscious progression through this early stage of the pipeline. As a result, it is hoped that they might make better informed choices when they approach the first decision point.

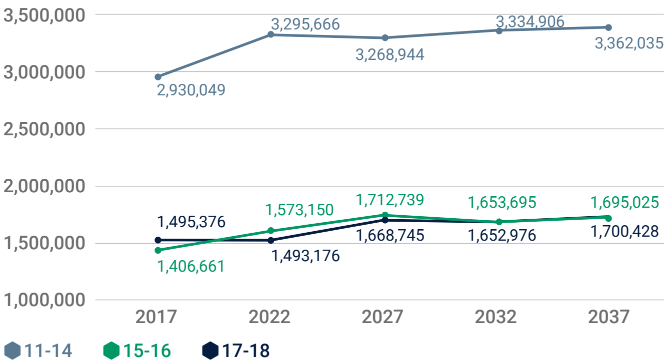
3.3 – Population trends

A key factor determining flow into the pipeline that cannot be influenced is the number of young people entering secondary education. This section summarises our current understanding of how the UK's population is changing, with the focus on likely future numbers of young people (Figure 3.2).

In 2016, the UK population was a record 65.6 million, and projected to reach 74 million by 2039.[3.3] From the high population growth of the 1960s baby boom, growth slowed in the 1970s. In the late 1980s, the total population began to grow once more, when the baby boomers began having children. In each of the last three years, net migration of 250,000 or more – partly relating to the expansion of the European Union – has added significantly to the 'natural' expansion of the UK population.

The population is also getting older, thanks to improvements in healthcare and lifestyles. People aged 65 and over are projected to account for a quarter of the total UK population by 2046. Life expectancy is increasing and girls born this year can expect to live around 83 years on average: 4 years more than those born 15 years ago. Men have seen an even greater increase in life expectancy, with an average approaching 80 years.

Figure 3.2 National population projections for age groups 11 to 14, 15 to 16 and 17 to 18 (2017 to 2037) – UK



Source: ONS, 2017

Increased life expectancy, along with lower birth rates, have led to the UK's population of children declining from 25% in 1976 to 19% in 2016, with further decline predicted. However, high net migration has gone some way towards countering our ageing population. Immigrants – most of whom are aged between 20 and 36 – make a significant contribution to the birth rate. In fact, 2012 had the highest birth rate since 1990.

Figure 3.3 shows population projections for the UK for the next 20 years. Total population is set to grow by around 3% over the next 5 years and by over 11% in the next 20 years.[3.4] The number of young people is set to rise, even though they are a decreasing proportion of the overall population. The projections show that a recent dip in the number of young people has nearly worked its way through the yearly profiles. In the next 5 years, studies project considerable increases in the number of 12 to 16 year olds (although the dip can still be seen in decreases in 18 to 21 year olds). Over the next 20 years, all age groups will grow, especially teenagers in secondary education. This is encouraging for the potential engineering talent pool.

Regional variations

The size and age profile of the population varies across the UK, with the focus of growth still firmly on London and south east England. London's population is expected to grow by over 6% by 2022 and 11% by 2027. In contrast, overall growth rates in the North East and North West of England, and in Scotland and Wales, are all expected to be less than 2% by 2022 and only around 3% by 2027.

Geographical profile trends follow a similar pattern, with the strongest growth in the number of young people expected to be in London, the South East and East of England. Growth in Scotland, Wales and the North East of England will be much lower.

Over the next 20 years, the number of young people is set to rise, an encouraging prospect for the potential engineering talent pool.

Diversity trends

The male population is set to rise slightly more than the female population. Largely, this is due to increasing male life expectancy, but a slight increase in the proportion of young males is also predicted. Gender differences, however, are insignificant compared with expected changes in the ethnic profile of people in the UK and especially young people.

The 2011 Census provides the most recent data on ethnic background. At that time, white British was the dominant ethnic group, accounting for 87% of people of known ethnicity in the UK. Behind the headline figure, however, is a more nuanced picture. The national average is influenced heavily by ethnically-diverse London, where only around half of the population were white British, 18% were Asian or Asian British and 13% were black or black British in 2011. In the West Midlands, over 10% classed themselves as Asian. This contrasts with the North East and South West, Scotland and Northern Ireland, where 95% categorised themselves as white. The concentration of the UK's non-white population in large urban areas has been highlighted by Policy Exchange, which states that "just three cities (London, Greater Birmingham and Greater Manchester) account for over 50% of the UK's entire BME [black and minority ethnic] population."[3.5]

This pattern of overall white dominance is set to change, however, because ethnic minorities account for a much higher proportion of the young population than of the old.

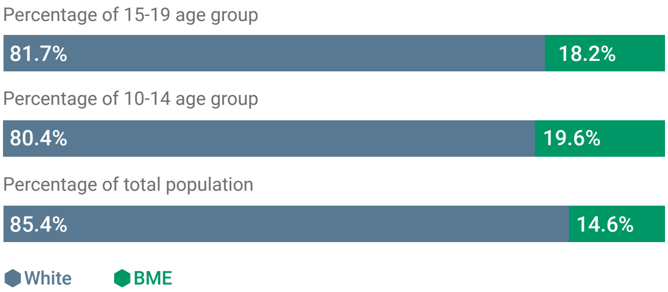
3.3 ONS. 'Overview of the UK population: July 2017', July 2017.
3.4 ONS. 'National Population Projections, Principal Projection' - UK Population Single Year of Age, 2014-based, October 2015.
3.5 Policy Exchange. 'A Portrait of Modern Britain', May 2014, p7.

Figure 3.3 National population projections for ages 7 to 21 and 65 (2017 to 2037) – UK

Age	2017	2022	2027	2032	2037	5-year percentage change (2017 to 2022)	20-year percentage change (2017 to 2037)
7	811,955	797,347	824,739	828,984	819,835	-1.8% ▼	1.0% ▲
8	803,511	803,882	823,155	832,563	822,855	0.0%	2.4% ▲
9	809,294	824,227	820,530	834,937	826,267	1.8% ▲	2.1% ▲
10	782,325	850,438	816,653	835,719	829,996	8.7% ▲	6.1% ▲
11	766,236	838,556	812,493	835,434	834,453	9.4% ▲	8.9% ▲
12	736,601	822,564	807,476	834,878	839,142	11.7% ▲	13.9% ▲
13	723,764	814,267	814,191	833,480	842,902	12.5% ▲	16.5% ▲
14	703,448	820,279	834,784	831,114	845,538	16.6% ▲	20.2% ▲
15	693,354	794,044	861,726	827,979	847,066	14.5% ▲	22.2% ▲
16	713,307	779,106	851,013	824,997	847,959	9.2% ▲	18.9% ▲
17	734,088	751,143	836,676	821,650	849,066	2.3% ▲	15.7% ▲
18	761,288	742,033	832,069	832,045	851,362	-2.5% ▼	11.8% ▲
19	779,049	729,591	845,822	860,384	856,764	-6.3% ▼	10.0% ▲
20	812,448	729,399	829,335	897,049	863,391	-10.2% ▼	6.3% ▲
21	824,990	758,845	823,645	895,573	869,648	-8.0% ▼	5.4% ▲
65	672,482	734,696	847,783	882,399	840,619	9.3% ▲	25.0% ▲
All ages	**66,029,928**	**68,202,846**	**70,234,132**	**72,053,345**	**73,672,863**	**3.3% ▲**	**11.6% ▲**

Source: ONS, 2011

Figure 3.4 Percentage of population by broad ethnic group and age group (2011) – England



Source: ONS census, 2011

The 2011 Census data showed in that England just under 82% of 15 to 19 year olds were white British, and 80% of 10 to 14 year olds, compared with 85% overall (**Figure 3.4**). These differences were due to higher proportions of black, Asian and especially mixed or multiple ethnic backgrounds amongst the young (**Figure 3.5**). The proportion of 10 to 14 year olds with mixed or multiple ethnicity was twice as high as in the overall population. It is thought that ethnic minorities comprise as much as 25% of those aged under 5 years, whereas they only constitute about 5% of the English population aged over 60. However, some models suggest that by 2051 BME communities could represent as much as 30% of the UK's total population.[3.6]

Figure 3.5 Population by young age group and broad ethnic group[3.7] (2011) – England

	Percentage of total population	Number of 10 to 14 year olds	Percentage of 10-14 age group	Number of 15 to 19 year olds	Percentage of 15-19 age group
White	85.4%	2,477,722	80.4%	2,729,955	81.7%
BME total	14.6%	603,207	19.6%	610,310	18.3%
Mixed/multiple ethnic group	*2.3%*	*138,048*	*4.5%*	*126,931*	*3.8%*
Asian/Asian British	*7.8%*	*286,140*	*9.3%*	*301,350*	*9.0%*
Black/African/Caribbean/black British	*3.5%*	*144,439*	*4.7%*	*144,245*	*4.3%*
Other ethnic group	*1.0%*	*34,580*	*1.1%*	*37,784*	*1.1%*
All ethnic groups	**100.0%**	**3,080,929**	**100.0%**	**3,340,265**	**100.0%**

Source: ONS census, 2011

3.6 Policy Exchange. 'A Portrait of Modern Britain', May 2014, p6.
3.7 Categories are those used by the ONS at top-line UK harmonised level. For further information see Harmonised Concepts and Questions for Social Data Sources: Primary Principles - Ethnic Group, ONS, May 2015.

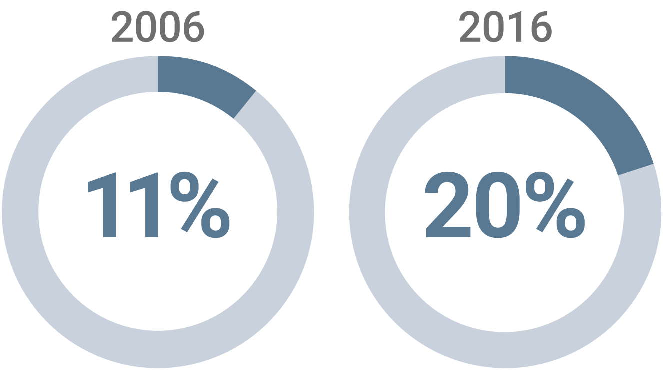
It is worth noting that these projections are based on 10-yearly census data and computer modelling of birth and mortality rates. They cannot take full account of short-term shifts in the nationality profile of the population due to immigration, which may impact ethnicity. Nevertheless, the key point is that ethnic diversity among the young is growing, and this needs to be taken into account when considering the future flow of talent into the engineering skills pipeline.

Social mobility

Another aspect of population change relates to social mobility, although this is much harder to measure. Participation in HE has traditionally been used as a yardstick for the overall prospects of the UK's young. Participation is at an all-time high: 43% of 19 year olds in England had entered HE by 2016.[3.8] However, early figures for 2017 university entry suggest that growth may be tailing off.

Between 2006 and 2016, the percentage of HE students from disadvantaged areas almost doubled from 11% to nearly 20%, although much of that increase was at less selective universities (**Figure 3.6**).[3.9] This widening of access is thought to result from higher school attainment, intensive efforts to widen participation, the removal of the cap on HE student numbers, and more availability of HE degrees at FE colleges.[3.10] There is little evidence to date that increased tuition fees have deterred students from poorer backgrounds from going to university.[3.11] Yet despite these improvements, students from lower socioeconomic backgrounds are still far less likely to attend university than their counterparts from more advantaged backgrounds.

Figure 3.6 Percentage of HE students from disadvantaged areas (2006 and 2016) – UK



Source: UCAS, 2017

Even when they do go to university, graduates from disadvantaged backgrounds are less likely to complete their degrees and enter professional jobs. They also tend to earn less than other graduates (although they usually earn more than those without degrees).[3.12]

Case study – Aspiring Professionals Programme (CH2M)

Sam Daly, Business Development Manager, CH2M

CH2M helps unlock new engineering talent by supporting the Social Mobility Foundation. We are proud to be involved in the Aspiring Professionals Programme (APP), a residential week for 20 students chosen from across the UK who fit the eligibility criteria:

- Year 12 students (aged 16 to 17)
- If they attend a school with a GCSE pass grade above 50%, they must have at least 5 A grades
- If they attend a school with a GCSE pass grade below 50%, they must have at least 4 A grades
- Predicted to achieve at least ABB at A level
- Be either personally eligible for free school meals (household income below £16,190) and/or be the first generation attending university from a school with at least 20% of pupils who are eligible for free school meals.

The programme provides a week of activities, presentations and project visits to deepen students' understanding of engineering. The students are also given a mentor for the year who helps them apply for higher education courses and supports them in practical tasks, such as writing a personal statement and practising for interviews.

The impact on students' educational outcomes has been impressive. Out of the 2014 and 2015 placements, 63% of students went on to Russell Group universities. In 2016, 95% of students said they would not have been able to secure an internship without our support. In 2017, CH2M interviewed 11 candidates from our 2016 placement year for prospective employment. CH2M has recently completed our fourth consecutive year of the residential programme.

3.8 UCAS. '2016 End of Cycle Report', December 2016.
3.9 UCAS. 'Equality and entry rates, 2017.
3.10 Social Mobility Commission: 'Time For Change: An Assessment of Government Policies on Social Mobility 1997-2017', June 2017.
3.11 Social Mobility & Child Poverty Commission. 'The Social Mobility Index', January 2016.
3.12 IFS. 'Heterogeneity in graduate earnings by socio-economic background', October 2014.

The Social Mobility Index is another measure of lifetime outcomes, reflecting academic studies that suggest educational attainment plays a crucial part in a child's life chances. The index compares the chances of a child from a disadvantaged background doing well at school, going on to higher education and getting a good job, across each local authority in England.[3.13] It also considers outcomes achieved by adults in that area: what their average income is, how likely they are to take on low-paid work or get a professional-level job, whether they own a home and what they spend on housing. Together, these elements paint a picture of the likelihood of someone converting a good education into a good life. The results show substantial differences between different parts of the country, and also unexpected local variations. Amongst the conclusions drawn are that:

- London and its commuter belt are pulling away from the rest of England. Young people from all backgrounds living in these areas are far more likely to achieve good outcomes in school and have more opportunities as adults than those in the rest of the country.
- Many coastal areas and industrial towns are becoming social mobility 'coldspots' as they perform badly on both educational measures and adulthood outcomes.
- Other than London, England's major cities are not necessarily the places of opportunity that they might be. No other major English city performs well in the Index. Manchester, Birmingham and Southampton are all about average while Nottingham, Derby and Norwich perform badly.
- While there is some link between the overall affluence of a local area and the life chances of disadvantaged young people, many affluent areas fail young people from poor backgrounds.

Greater social mobility means that the talents of more young people are being recognised and used. There is evidence that students from lower socio-economic backgrounds are more likely to pursue STEM subjects than some other subjects such as law or medicine.[3.14] Growth in demand for STEM skills could then be good news for overall social mobility.

To maximise flow into the pipeline, engineering will need to be as inclusive as possible. We need to draw in people from an increasingly ethnically-diverse young population, and make sure that children from disadvantaged backgrounds can pursue the educational pathways they need to transition successfully into engineering employment.

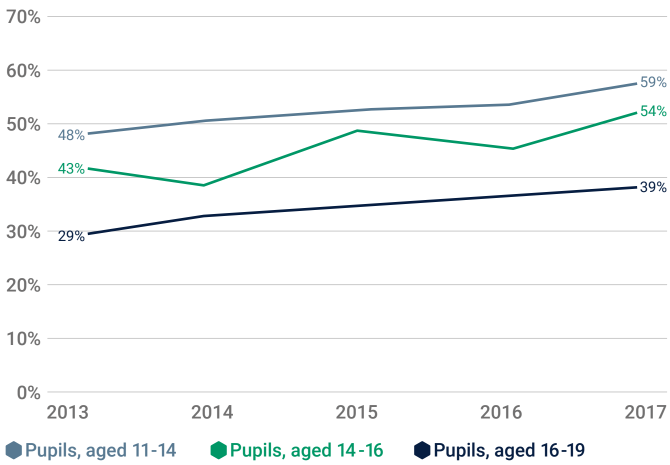
3.4 – Perceptions and attitudes about engineering

The Engineering Brand Monitor (EBM)[3.15] is EngineeringUK's annual survey of engineering and STEM perceptions among nationally-representative samples of young people, adults and STEM educators. Results from the EBM between 2013 and 2017 suggest that, overall, perceptions about engineering and STEM have improved in recent years.

Consideration of an engineering career

The proportion of young people aged 11 to 19 who would consider a career in engineering has risen from 40% in 2013 to 51% in 2017, with all age groups showing an upward trend (Figure 3.7). However, the older pupils get, the less likely they are to consider a career in engineering: 39% of 16 to 19 year olds in 2017 would consider engineering, compared with 59% of 11 to 14 year olds. While this may partly be due to older pupils having clearer career aspirations and solidifying their plans, it also confirms that sustaining young people's interest as they progress through secondary education is a key challenge.

Figure 3.7 Young people between ages 11 and 19 who would consider a career in engineering (2013 to 2017) – UK

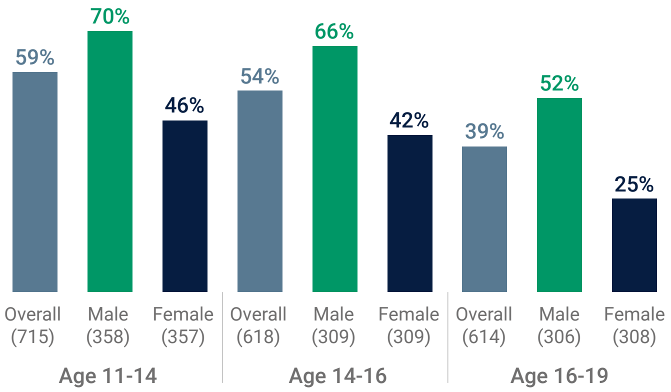


Source: EngineeringUK, EBM 2013-2017

3.13 Social Mobility & Child Poverty Commission. 'The Social Mobility Index', January 2016.
3.14 BCG. 'The state of social mobility in the UK', July 2017.
3.15 Prior to 2016 this was called The Engineers and Engineering Brand Monitor (EEBM).

Figure 3.8 shows clear differences in levels of interest in engineering among female and male pupils. Boys are far more likely to consider a career in engineering than girls at every age. Interest drops off for both boys and girls as they get older, but this is particularly pronounced for girls after the age of 16.

Figure 3.8 Proportions of girls and boys between ages 11 and 19 who would consider a career in engineering (2017) – UK

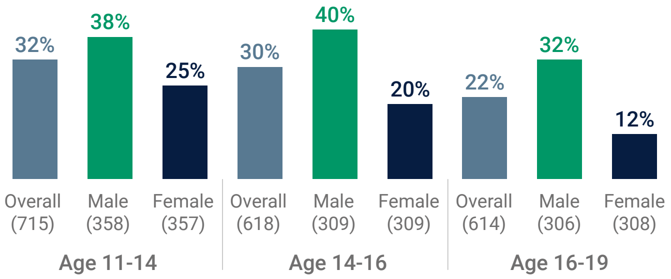


Source: EngineeringUK, EBM 2017

Adult respondents showed similar gender differences, with more than twice as many men as women saying they had considered a career in engineering (38% compared with 14%).

When asked if they probably or definitely wanted to become an engineer, 3 in 10 young people who responded to the EBM 2017 said yes (**Figure 3.9**). Again, the trend was consistent: 31% of 11 to 16 year olds said yes, but this dropped off by age (22% of 16 to 19 year olds) and was a more likely response from boys than girls.

Figure 3.9 Proportion of girls and boys between ages 11 and 19 who want to become engineers (2017) – UK



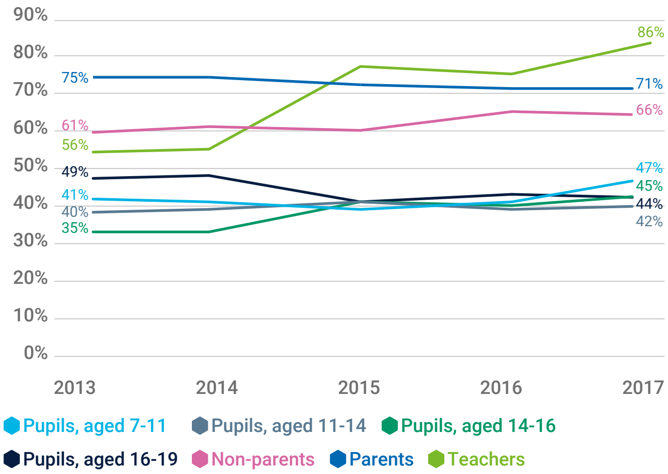
Source: EngineeringUK, EBM 2017

Desirability of an engineering career

The EBM suggests that more pupils now perceive engineering as a desirable career, particularly at the younger end of the spectrum (**Figure 3.10**). In the 14 to 16 bracket, 45% of pupils thought engineering was a desirable career in 2017, compared with 35% in 2013. Again, this figure fell slightly for 16 to 19 year olds.

Notably adults and teachers were more likely than the young people themselves to view a career in engineering as desirable for their children, other young people, or their pupils. In fact, in some cases teachers were twice as likely as pupils to hold this view in 2017.

Figure 3.10 Proportion of parents, non-parents, educators, and pupils aged 7 to 19 who believe a career in engineering is desirable (2013 to 2017) – UK

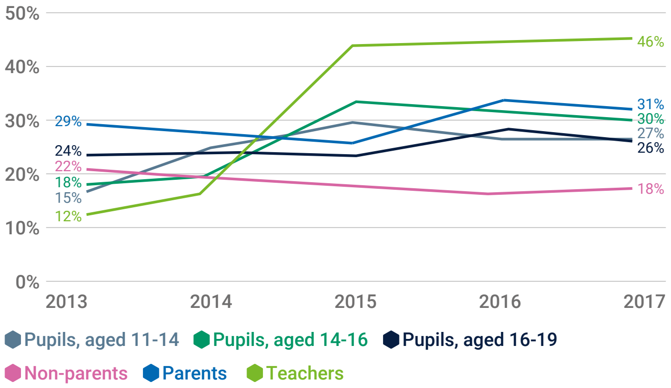


Source: EngineeringUK, EBM 2013-2017
Proportions relate to those who gave a score of 4+ (on the 5-point scale) for the question, 'How much do you know about what people working in engineering do?', with 1 being 'know almost nothing' and 5 being 'know a lot'. The term 'non-parents' is used to refer to adults in the general public who do not have children.

Understanding of engineering

Respondents to the EBM survey are asked how much they know about what people working in engineering, science and technology do. There has been some progress in recent years: 27% of 11 to 14 year olds and 30% of 14 to 16 year olds reported an understanding of engineering in 2017, compared with 15% and 18% in 2013 (**Figure 3.11**). And while understanding among adults outside the educational arena are unchanged, there has been a marked rise in knowledge of engineering amongst teachers.

Figure 3.11 Proportion of parents, non-parents, educators, and young people aged between 11 and 19 who say they know what people working in engineering do (2013 to 2017) – UK



Source: EngineeringUK, EBM 2013-2017
Proportions relate to those who gave a score of 4+ (on the 5-point scale) for the question, 'How much do you know about what people working in engineering do?', with 1 being 'know almost nothing' and 5 being 'know a lot'. The term 'non-parents' is used to refer to adults in the general public who do not have children.

In all age ranges, male pupils were more likely than females to say they know what people working in engineering and in technology do. (Figure 3.12). However, gender differences were less pronounced on the question of what scientists do.

Across all ages, pupils were less likely to understand engineering careers than science or technology careers. Together, these results suggest that there is work to be done in informing young people, especially girls, about what a career in engineering can entail.

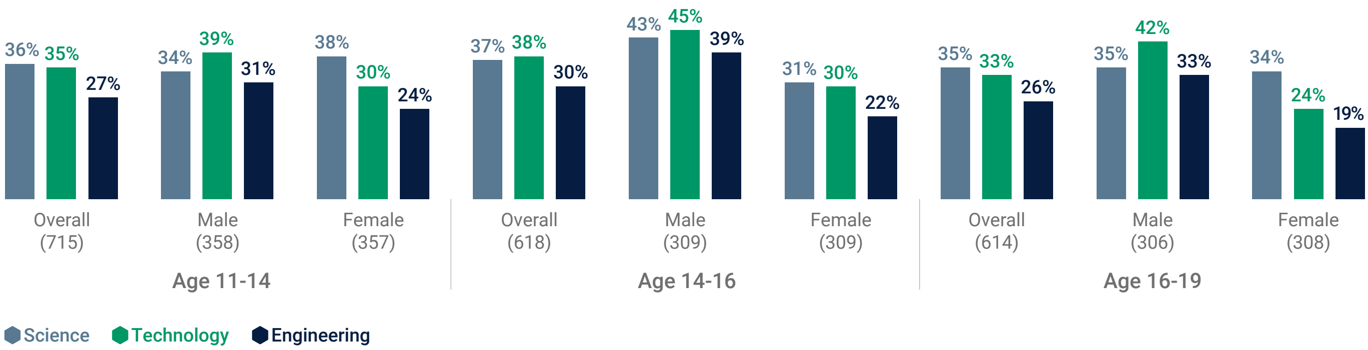
Amongst parents, men (40%) were more likely than women (22%) to say that they know what engineers do - a difference that also applied to knowledge about science (18 percentage points) or technology (15 percentage points). Understanding of the engineer's role increases among teachers (46% in 2017). However, these results suggest that parents are not much more knowledgeable than young people about what constitutes engineering. This is concerning if young people rely on parental advice when making decisions about subjects and progression.

3.5 – Factors in subject and career choices

Policy-makers often rely on the theory of rational action: believing that if someone knows something is in their best interests, they will do it.[3.16] As a result, there have been many drives to make information available about opportunities and the benefits of various decisions, empowering people to make 'informed choices'. However, evidence increasingly suggests that many career-related decisions are not simply rational.[3.17] It's important to understand how young people make these choices. This could provide greater insight into how perceived 'best interest' can be turned into an increased flow of qualified young people through the engineering pipeline.

Research into young people's career decisions has identified a wide range of influences and influencers. External factors include information about career opportunities and less direct influences such as television and digital media. Social factors such as personality and characteristics (such as gender) or background also play a part. These converge with drivers such as enjoyment or perceived ability in key STEM subjects at school. The people influencing these decisions include parents/guardians, peers and significant others, as well as teachers and careers professionals.

Figure 3.12 Proportion of girls and boys aged between 11 and 19 who say they know what people working in engineering, technology and science do (2017) – UK



Source: EngineeringUK, EBM 2017
Proportions relate to those who gave a score of 4+ (on the 5-point scale) for the question, 'How much do you know about what people working in engineering do?'

3.16 Becker, G. 'The Economic Approach to Human Behavior, University of Chicago Press', 1976.
3.17 HEFCE. 'UK review of the provision of information about higher education: Advisory study and literature review', April 2014.

Figure 3.13 Moments of choice model and factors in decision-making by young people

Contextual factors

These factors can inform a sense of what is attainable, and create a 'running hypothesis' of likely career or post-school destination.

Community setting

- Community destination rooms
- Industries & employers that loom large locally.

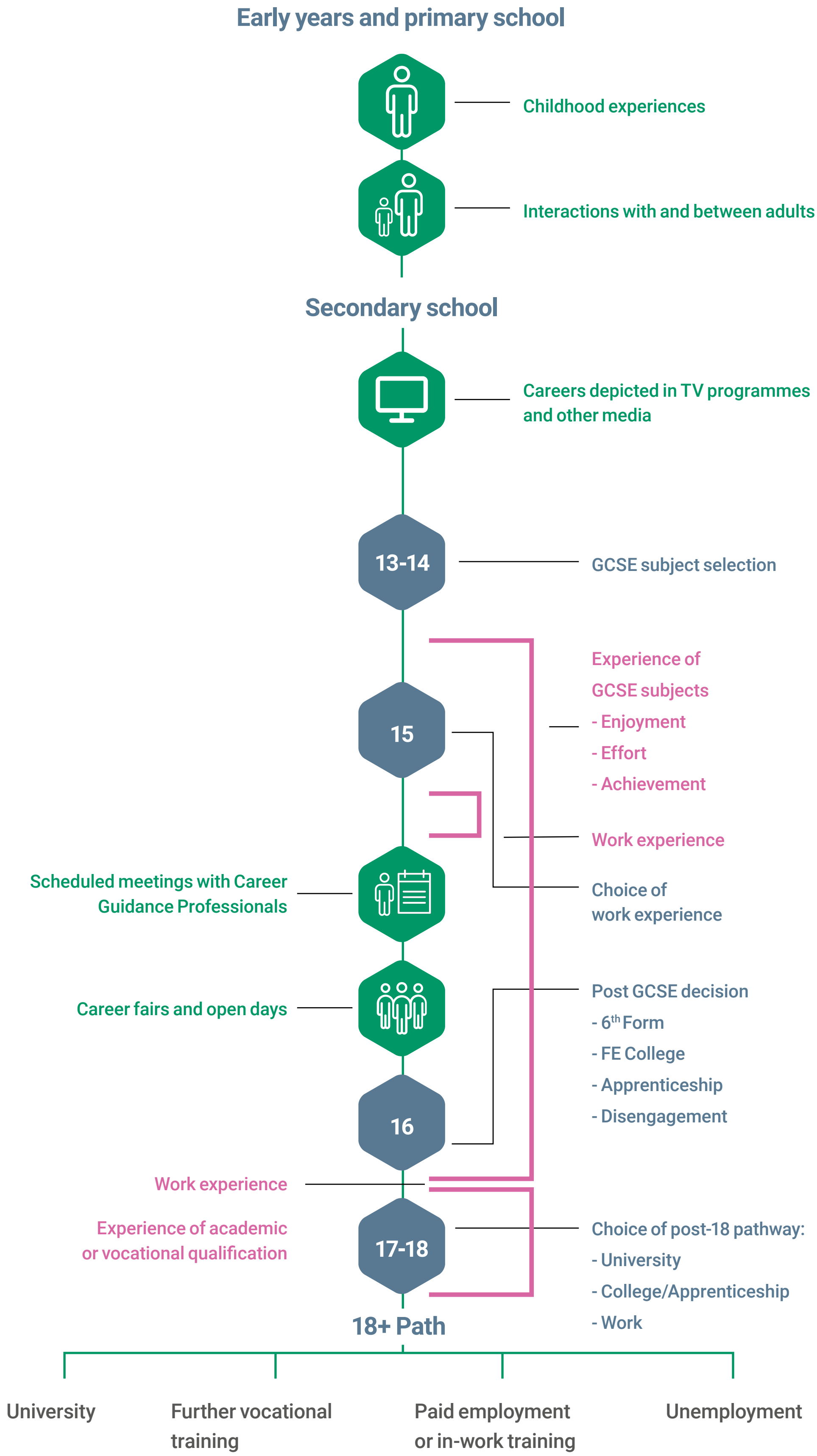
Home setting

- Parental aspirations
- Family destination norms
- Cultural norms

Hard choice prompts: moments where a neccesary decision with immediate consequence forces the consideration of career options. These occur at set times, so approximate age is noted in the circle.

Feedback points: the resulting experience of a decision, which can either reaffirm a student choice or lead them to reconsider their career direction. These are represented with a range over which students can develop a view as to their decision.

Idea-forming events: can be planned or unplanned, and plant the seed for a student to consider a particular job, career or study pathway. These can happen at any moment, and with varying frequency. They are placed for illustrated purposes only.



Source: Careers & Enterprise Company, 2016

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For a young person, these influences create an evolving view of the world and their current and potential position in it, built on both rational thinking and instinctive or emotional drivers. The Careers & Enterprise Company's research into the way young people make these decisions concludes that this multitude of – sometimes conflicting – influences may result in them forming a world view unconducive to what rationally seem to be the 'best' decisions about their future.[3.18] In relation to parental advice, for example:

- Young people refer disproportionately to jobs that were common during their parents' youth rather than those that are available today.
- Parents are prone to believe that their own education is the most appropriate for their own children. While many parents who went to university feel that apprenticeships are now a good option, very few recommend them for their own children.
- Young people are more likely to view university as their ideal choice over other routes, even when it is either unachievable or unnecessary for their expected career.

Based on its own research and recently commissioned work,[3.19] the Careers & Enterprise Company has depicted the decision-making journey for young people. Usefully, this depiction maps easily onto the pipeline for engineering skills (Figure 3.13). It identifies 'moments of choice' in a typical journey.

Tellingly, the potential for disconnections between important moments where young people are inspired by an external event – such as a museum visit or a social encounter – and the moments when they need to make decisions, is evident. At decision points, they deliberately seek information. But it is the more emotionally-powerful moments of inspiration from the other influences that may drive their overall direction and, ultimately, their career.

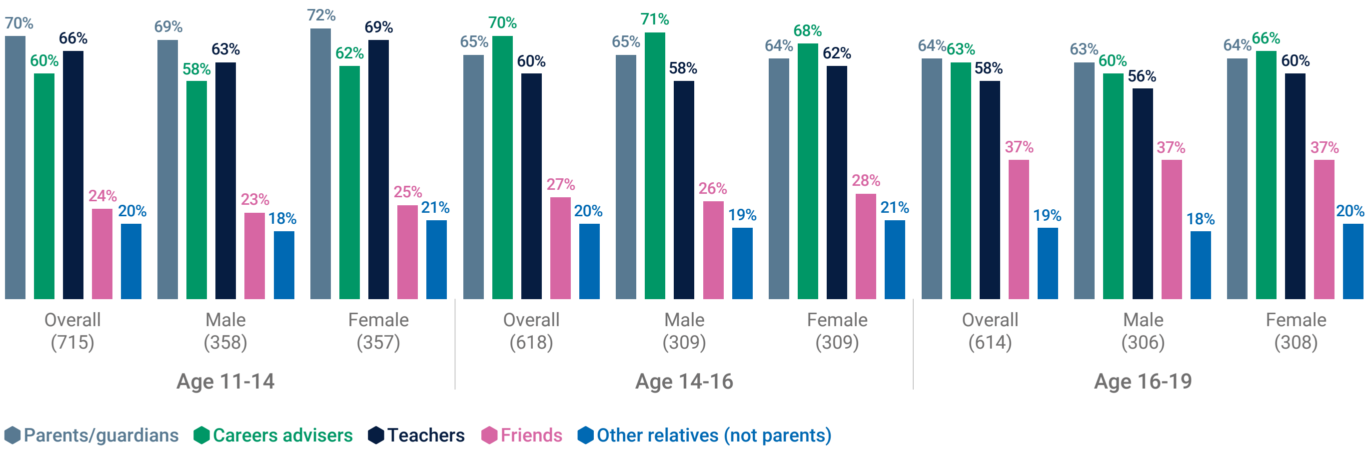
The moments of choice model provides a useful backdrop against which to consider possible interventions. A number of these are treated in more detail later in this chapter.

Influences and influencers

In our EBM research, pupils are asked who they would consider going to for careers advice, and also whose advice they were most likely to act on. Across all the age groups, pupils were most likely to consider going to parents/guardians, careers advisers and teachers for advice about careers, compared with other potential sources such as friends (Figure 3.14).

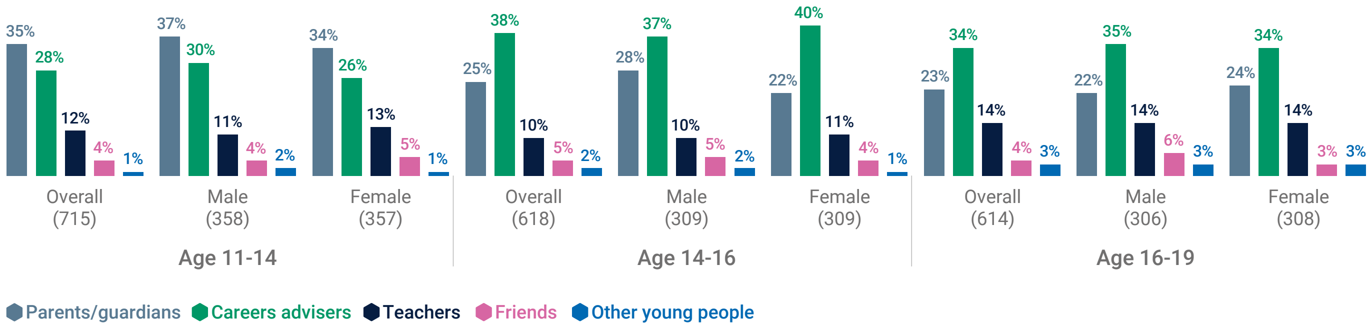
Pupils aged 11 to 14 were most likely to consider and act on advice from their parents/guardians, whereas those aged 14 to 19 were more likely to act on advice from careers advisers (Figure 3.15). Strikingly, less than 1 in 6 of any of the groups analysed thought that they would act on teachers' advice.

Figure 3.14 Top 5 sources of careers advice that pupils aged 11 to 19 would consider (2017) – UK



Source: EngineeringUK, EBM 2017

Figure 3.15 Top 5 sources of careers advice that pupils aged 11 to 19 would act on (2017) – UK



Source: EngineeringUK, EBM 2017

3.18 The Careers & Enterprise Company. 'Moments of choice - How education outcomes data can support better informed career decisions', August 2016.
3.19 Behavioural Insights Team. 'Moments of choice, research final report', August 2016.

While the important role of parents or guardians in influencing young people's careers decisions – especially at the crucial 11 to 14 stage – is clear, the contribution of careers advisers is less certain. Later in this chapter we cover limitations to the provision of personalised careers support in many schools, meaning that young people may not have access to careers advisers as a source of advice.

Research suggests that young people consider a range of factors in deciding whether to study STEM subjects. One of these is whether they can see the subject's relevance to a potential career.[3.20] However, their interest in and enjoyment of science and maths, their belief they can do well in these subjects, and encouragement from teachers are also critical. The ASPIRES project, based on longitudinal research with young people, reveals that most do enjoy science at school. They also have some inherently positive views of scientists but have poorly formulated views (or none) of what science or engineering jobs actually entail, beyond being a science teacher.[3.21] EBM results similarly confirm that around 70% of young people of both primary school age and the 11 to 14 bracket do enjoy science in school, and over half enjoy mathematics. This may reflect their inherent positivity about many subjects at this age, rather than marking these subjects as the most enjoyable.

Pupils of all ages were asked whether they had taken part in a range of science-related activities outside school. High proportions of 7 to 11 year olds have done at least one science-related activity outside school (78%). This proportion appears to have been rising slightly in recent years. Figure 3.16 illustrates that the most common activities are to visit science museums or exhibitions and to watch science programmes. There is some evidence of a slight difference by gender, with fewer girls taking part in these science-related extracurricular activities than boys.

Once again, our EBM shows positive signs: growing numbers of young people are enjoying science at primary school and in key stage 3, and are enjoying extra-curricular activities that may inspire them to continue studying science. They also appear to be open to well-intentioned (if not always well-informed) influence from parents/guardians, teachers and careers advisers.

3.6 – Interventions

This section focuses on ways the engineering community and others could build on this increase in positivity towards engineering, to sustain the flow of talented young people through the skills pipeline.

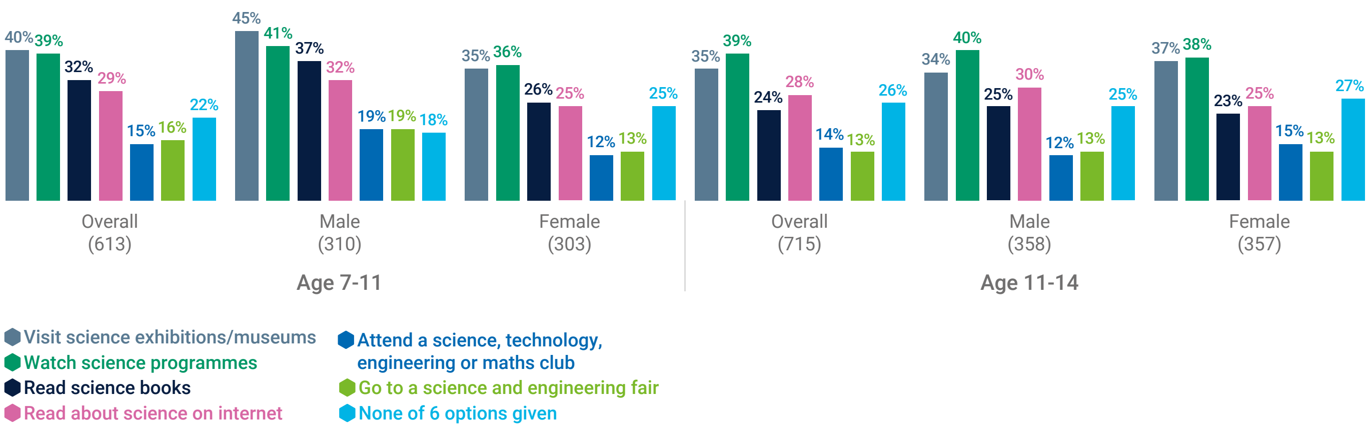
There are four broad types of intervention that could maximise momentum towards the pipeline during the secondary education stage:

- improvements to curriculum teaching in school
- careers education, advice and guidance
- extra- or co-curricular inspiration activities (including those traditionally called 'enrichment')
- employer engagement and workplace experiences

The following sections focus on the last three of these interventions, highlighting current activity and providing evidence of impact.

It is beyond the scope of this chapter to give a detailed treatment of how STEM curriculum teaching is evolving. However, we do examine concern over the supply of STEM teachers in Chapter 4. It is also worth mentioning at this point the increasing interest in bringing career-related context into subject learning. This interest results from educators recognising that the more relevant STEM subject teaching is to learners' future lives, the more likely it is to be effective – especially if it includes 'real life' applications that they might come across in employment. For best effect, curriculum-

Figure 3.16 Participation in science-related activities outside school by pupils aged 7 to 14 (2017) – UK



Source: EngineeringUK, EBM 2017

3.20 King's College London: 'Understanding Physics and Maths Participation survey of 14-15 year olds', 2008.
3.21 IoE. ASPIRES 2: 'Longitudinal research project studying young people's science and career aspirations', 2017.

based careers awareness should be complemented with careers provision outside the curriculum[3.22] and the pastoral influence and support of teachers.

Supporting this notion, the Institution of Mechanical Engineers urges a greater focus in schools on the presence of engineering and the 'made world' at all stages, from primary level upwards.[3.23] As major changes to the core curriculum seem unlikely, it recommends working within existing educational frameworks: "Enhancing teachers' confidence and ability to embed frequent references to engineering and engineering careers within their teaching would not only support their pupils in making choices, but also emphasise that, although science and mathematics are the prevalent STEM subjects in schools, in the external world it is engineering and technology that predominate."

One continuing professional development programme for teachers that directly supports this aspiration is the STEM Insight programme. Through this scheme, STEM teachers or other educators take part in a week-long placement in industry which offers them a personal insight into a current engineering or technology workplace. This allows them to reference 'real' jobs and careers within their teaching. It also fosters ongoing engagement between the host employer and the school,[3.24] which supports current strategies to increase the involvement of businesses in schools and colleges.

Careers education and guidance

Economists and educationalists recognise that high-quality careers support helps effective functioning of the education system as well as the labour market and the economy, and can enhance social justice.[3.25] Access to engineering careers requires a well-functioning system of careers education and guidance, not least because of the large number of potential entry routes to the complex engineering domains. Young people may need professional help to understand the progression pathways into engineering and/or the personal and professional characteristics that engineering employers are looking for.

Current provision

Almost every recent piece of research or commentary on STEM educational progression or the supply of skills into the labour market concludes that careers advice to young people is inadequate.[3.26] This observation masks two important questions: what is the availability of careers provision in its varying forms, and what is the impact of that provision on young people?

A national survey of over 13,000 year 11 students (aged 15 to 16 years) in England, supported by longitudinal research with those aged 10 to 16, suggests that careers education and young people's engagement with careers information are both patchy and "patterned by social injustices".[3.27] It reports that less than two-thirds have received careers-related education and that careers work in schools is not reaching those most in need.

Furthermore, a 2015 survey of schools in England found that:

- a third of schools had dropped careers education from the curriculum, and only just over half provided any careers education in years 7 or 8
- under half of schools included work-related learning in the curriculum in any secondary year other than year 10 (when almost two-thirds of schools organised some activities with employers)
- while many schools were making personalised career guidance available to some students who need support, in 43% of the responding schools the adviser was not qualified to a level considered to constitute 'professional' guidance
- half the schools do not have a middle-level or more senior leader responsible for career education and guidance[3.28]

Case study – Innovate TfL in association with Cleshar

James Lloyd, Resourcing Manager – School Skills, Transport for London

Under-represented groups in schools in the poorest parts of London are the focus for TfL's new approach to supporting the pipeline of young people into level 2 to level 6 apprenticeships. The programme builds on the success of our School Skills Pathway, inspiring, engaging and empowering pupils from primary schools through to year 13. Positive results are already evident.

Working with teachers, parents and youth groups, volunteers from across the business are changing perceptions about transport and engineering, whilst providing young people with the skills they need for their next steps in life. Our activities include providing tailored support for schools, hosting community events, and ensuring fair access to work experience through Innovate TfL in association with Cleshar (the TfL Schools Challenge).

Innovate TfL in association with Cleshar provides simulated work experience for year 12 and 13 students alongside the curriculum. Students research and develop an innovation for TfL based on real life challenges. The in-school element of the project flexes to the needs and subject specialisms of the school and cohort of students. By including a broad range of project roles and responsibilities within the teams, we have increased the participation of girls to 35%.

Students can win a place at the final event, where they present in front of more than 100 senior transport professionals and win work experience with TfL as well as prizes. Team AMHR engineers from City and Islington College won the 2016/17 Innovate challenge, with their idea for piezoelectric seating, which converted kinetic energy into electricity for use on TfL vehicles. Registrations for the 2017/18 programme already stand at 19 schools and colleges, including five girls' schools.

www.tfl.gov.uk/innovate

3.22 Teach First: 'Careers education in the classroom - The role of teachers in making young people work ready', March 2015.
3.23 Institution of Mechanical Engineers: 'Big Ideas: The Future of Engineering in Schools', April 2016.
3.24 STEM Learning: 'STEM Insight'.
3.25 Hughes, D. Careers work in England's schools: politics, practices and prospects, 'British Journal of Guidance & Counselling', 2017.
3.26 Eg CBI. The right combination - CBI/Pearson Education and Skills Survey 2016, July 2016; Warwick Institute for Employment Research. VETrack: Longitudinal Study of Learners in Vocational Education, Wave 1 Report, November 2016.
3.27 Moote, J., & Archer, L. 'Failing to deliver? Exploring the current status of career education provision in England', Research Papers in Education, 2017.
3.28 Career Development Institute with Careers England. 'Survey of Career Education and Guidance in Schools and Links with Employers', May 2015.

According to the sub-commitee on Education, Skills and the Economy, "inadequate careers guidance in many English schools is exacerbating skills shortages and having a negative impact on the country's productivity."

The Sub-Committee on Education, Skills and the Economy concluded in 2016 that "inadequate careers guidance in many English schools is exacerbating skills shortages and having a negative impact on the country's productivity."[3.29] It identified that many schools were not providing students with good quality careers information, advice and guidance. Provision was 'patterned', with girls, minority ethnic, working class and lower-attaining students less likely to receive careers education than their peers. Crucially, those who were unsure of their aspirations, or planned to leave education post-16, were significantly less likely to have access to recognisable careers education. To address this, the report recommended that Ofsted include a specific careers guidance judgment in its school inspections.

In January 2017, the All-Party Parliamentary Group on Social Mobility also raised concerns, describing the quality of careers advice as "too varied, leaving young people unaware about steps to build a career, especially in the most selective professions."[3.30] Employer organisations also consistently report that employers view careers advice as inadequate. An education and skills survey undertaken by CBI and Pearson, for example, found that 84% of businesses thought that "the quality of careers advice young people receive is not good enough."

Careers provision is often 'patterned', with girls, minority ethnic, working class and lower-attaining students less likely to receive careers education than their peers.

Current policy and recent history

In response to these, and other, somewhat damning opinions, and evidence about the current state of provision of careers support in England evidence, the recent Industrial Strategy[3.31] called for careers provision for people of all ages:

"Our improved education and skills system must be supported by high-quality careers provision… Careers provision continues to be patchy and inconsistent – both in schools and in later life. The government is reviewing the current careers offer for people of all ages, and will build on the best international evidence to publish a comprehensive strategy later this year for careers information, advice and guidance."

The current statutory guidance in England[3.32] maintains schools' duty to secure independent and impartial careers guidance for all year 8 to 13 pupils. It defines 'independent' as external sources of careers guidance and inspiration, which could include employer visits, mentoring, web services, and telephone and helpline access. The guidance puts particular emphasis on employer engagement, suggesting young people should be exposed to a range of careers first-hand and advising schools to "build strong links with employers." STEM's importance is emphasised: pupils should "understand that a wide range of career choices require good knowledge of maths and the sciences. Schools should ensure that pupils are exposed to a diverse selection of professionals from varying occupations which require STEM subjects." Reflecting policy emphasis on apprenticeships and vocational education pathways (now called 'technical education'), the guidance specifically mentions provision of access to advice on non-academic progression options. This is being bolstered by an amendment to the Technical and Further Education Act 2017, which requires schools to allow other educational bodies to access their students to inform them about approved technical education qualifications or apprenticeships (although this has yet to come into force). The statutory guidance exhibits some influences of the 2014 Gatsby report *Good Career Guidance*[3.33] and its proposed benchmarks, in addition to an emphasis on enterprise that hails from Lord Young's report *Enterprise for All.* [3.34]

At present, there are few incentives for school leaders in England to prioritise careers work, beyond what they interpret in the statutory guidance as a requirement.

Destination statistics have also now been included as a headline accountability measure for schools: they are now required to show the percentage of students who continue onto sustained education or employment after completing their 16 to 18 study (ie after A levels or other level 3 qualifications).[3.35] These were partly designed to encourage schools to make students receive the support needed for transitions to education or employment.

In 2015, the government also launched the Careers & Enterprise Company, an organisation whose aim is to broker relationships between employers and schools and colleges, and to assure provision of high-quality, work-related inspiration and guidance for more young people aged 12 to -18. It aims to catalyse the fragmented market of careers and enterprise, to support effective programmes, fill gaps in provision and

3.29 House of Commons. 'Careers education, information, advice and guidance, First Joint Report of the Business, Innovation and Skills and Education Committees of Session 2016–17,' July 2016.
3.30 All-Party Parliamentary Group on Social Mobility. 'The class ceiling: Increasing access to the leading professions', January 2017.
3.31 House of Commons. 'Building our industrial strategy: Green paper', January 2017, p45.
3.32 DfE. 'Careers guidance and inspiration in schools: Statutory guidance for governing bodies, school leaders and school staff', April 2017.
3.33 Gatsby Charitable Foundation: 'Good career guidance', 2014.
3.34 Young, D. Enterprise for all. 'The relevance of enterprise in education', June 2014.
3.35 DfE. '16 to 18 destination measures. Guidance and technical note for 2016 performance tables', January 2017.

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ensure coverage across the country.[3.36] The company provides support for schools through a network of enterprise advisers – volunteers from businesses and the public sector who work with school and college leaders to build employer engagement plans, drawing on their own local experience. They are supported by salaried enterprise coordinators based in Local Enterprise Partnerships. The company also provides investment funds to extend the activity of selected providers of careers or enterprise support who, focused on 'opportunity areas' (geographical areas that have been identified for having the weakest provision).

All this makes for a market-based system of support for schools that is unregulated, competitive and complex. There is concern that schools may lack experience in making purchasing decisions in such a market.[3.37] At present, there seem to be few incentives for school leaders in England to prioritise careers work, beyond what they interpret in the statutory guidance as a requirement and any moral duty they feel they have. There is potential to strengthen the focus on careers work through Ofsted a recommendation made by the Sub-Committee on Education, Skills and the Economy.

The Department for Education's Careers strategy, published in December 2017[3.38], has four main strands:

- Inspiring encounters with the world or work, and further and higher education
- Excellent advice and guidance programmes, supporting schools to meet the Gatsby benchmarks with Careers Leaders central to the approach.
- Support and guidance tailored to individual needs
- Using data and technology to support and inform careers choices, including labour market information.

It commits government to an action plan to be implemented by the end of 2020. The action plan includes testing and evaluating new approaches to careers provision with a focus on encouraging young people, especially girls into STEM jobs and understanding what careers activities have an impact at primary school level. The strategy commits to the provision of clear information about T levels to parents, teachers, young people and careers professionals.

The accountability question is not wholly answered by the new strategy. Ofsted will consider careers provision as part of its inspection of colleges, and the question for schools is kept alive with the commitment that:

"The Department will engage with Ofsted, as it reviews the Common Inspection Framework, to consider coverage of careers provision as part of the development of any planned changes to school and college inspection arrangements which will take effect from September 2019. In developing its approach to assessing careers provision as part of those changes, Ofsted will take account of the requirements within the new statutory guidance for schools, which is being updated to reflect the Gatsby Benchmarks[3.39]."

The current, marketised system of careers provision is unique to England. Northern Ireland, Scotland and Wales each have a government-funded, all-age national careers service directly involved in the planning and/or delivery of careers education, information, advice and guidance in schools. Their approaches vary.

For example, in Wales, Gyrfa Cymru (Careers Wales) essentially offers a 'careers discovery' model for young people of all ages.[3.40] However, its core budget has been halved in recent years and it increasingly has to target provision to priority groups within its face-to-face work in schools.

Northern Ireland set out the key components for an all-age system in its strategy for 2015 to 2020. This includes commitments to a quality assurance framework, e-delivery and labour market information, work experience and access to impartial advice.[3.41] There is a new statutory duty to ensure that individuals can access "impartial careers support from appropriately qualified practitioners" and to develop support for parents as well as young people.

Scotland's approach is broadly similar, with Skills Development Scotland, employer organisations and education authorities working together to develop a more comprehensive standard for careers guidance. They too will focus on all-age digital services including the My World of Work portal[3.42] and use of labour market information (LMI). They work in partnership with schools, alongside face-to-face independent and impartial careers coaching and guidance.

Impact of careers support

The Education Endowment Federation has carried out a review of international research into the impact of careers education over the last 20 years. It concludes that the evidence base is weak and fragmented.[3.43] This is mainly due to the complexity of the various elements of careers education and the differing ways in which they've been reported. The study defined careers education very broadly: "Careers-focused school and/ or college mediated provision, including career guidance and work-related learning, designed to improve students' education, employment and/or social outcomes." Experimental literature on careers education and robust studies on the impact of career counselling or guidance are largely absent, but longitudinal studies suggest that the way teenagers think about their futures does have a significant impact on their outcomes.[3.44] Broadly, the literature supports the hypothesis that careers education helps young people to understand the relationship between educational goals and occupational outcomes, which increases pupil motivation and application.

3.36 The Careers & Enterprise Company. 'Moments of choice - How education outcomes data can support better informed career decisions', August 2016.
3.37 Hughes, D. 'Careers work in England's schools: politics, practices and prospects, British Journal of Guidance & Counselling', July 2017.
3.38 DfE, 'Careers Strategy: making the most of everyone's skills and talents', December 2017.
3.39 Ibid. p20.
3.40 Gyrfa Cymru Careers Wales. 'Changing Lives - A Vision for Careers Wales', 2017–2020.
3.41 DELNI & DENI. 'Preparing for Success 2015-2020, A Strategy for Careers Education and Guidance', March 2016.
3.42 'My World of Work: The help you need for the career you want'.
3.43 Education Endowment Foundation. 'Careers education: International literature review', July 2016.
3.44 King's College London. 'ASPIRES Report: Young people's science and career aspirations', age 10 –14, December 2013.

The literature suggests that careers education will work best when interventions are personalised and targeted to individuals' needs from an early age, and could make a particularly important impact on young people from poorer backgrounds, who are more likely to have career aspirations misaligned with their educational ambitions.

What's more, evidence from the OECD[3.45] suggests that high-quality, independent and impartial career guidance for young people is key to supporting successful transitions into education, training and employment. It should be separate and complementary to delivery of more generic careers education in schools.

Careers education works best when interventions are personalised and targeted to individuals' needs from an early age. They could make a particularly important impact on young people from poorer backgrounds, who are more likely to have career aspirations misaligned with their educational ambitions.

The Careers & Enterprise Company states that it is committed to being evidence-based, building on 'what works'.[3.46] It suggests that there is evidence that careers and enterprise programmes can:

- improve young people's ability to make career decisions and their optimism about the future
- help young people to increase their attainment and be more likely to enrol in post-secondary education
- reduce young people's likelihood of becoming unemployed
- increase young people's earnings after they complete their schooling

It has reviewed research into the relative strength of evidence about different types of career- and enterprise-related interventions (summarised in Figure 3.17). A number of the more generic career-focused activities fall into the middle and lower categories of evidence on this basis, reflecting how few robust impact studies of these activities exist.

Figure 3.17 Strength of evidence base for impact for different career- and enterprise-related interventions in schools and colleges

Strong evidence

High quality evaluations showing positive impact

- employer mentoring
- enterprise competitions
- work related learning provided in cooperation with emplyers

Some evidence

Lower-quality evaluations showing positive impact

- 1-2 week work experiences
- career learning co-delivered by teachers and employers
- careers talks
- careers websites
- curriculum learning co-delivered by teachers and employers
- cv workshops
- employer delivered employability skills workshops
- enterprise activities
- mock interviews
- work place visits

Limited evidence

Insufficient evaluations evidence at present

- careers fairs
- e-mentoring
- job shadowing
- part time working
- teacher CPD delivered by employers
- volunteering

Source: Careers & Enterprise Company, 2016

3.45 OECD. 'Career Guidance and Public Policy: Bridging the Gap', 2004.
3.46 Careers & Enterprise Company. 'What Works in Careers and Enterprise?' December 2016.

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Quality in careers provision

The January 2017 statutory guidance from the Department for Education recommended that all schools should work towards achieving a careers Quality Award. These have been awarded by local providers of career guidance services, working in partnership with schools in their area, since 1992. Most offered the option of external assessment leading to accreditation. Over time, several of these awards expanded to cover more than one geographical area. However, the impetus for them largely disappeared with the advent of the national Connexions service. However, when the national service was dismantled, and responsibility returned to schools, the potential benefit of a quality award re-emerged. Meanwhile, a system of national validation was introduced in 2012 through the Quality in Careers Standard. This national validation process has recently been replaced by a national licensing scheme and, from March 2017, there has been one unified award called the Quality in Careers Standard, which requires external, qualified assessment.[3.47] The CDI, the professional body for careers professionals leading this work, is also campaigning for a qualified 'careers leader' in every school to provide better coordination of careers support.

The 8 benchmarks of good career guidance that were identified by the Gatsby Charitable Foundation (**Figure 3.18**) are becoming increasingly widely accepted.[3.48] They are, for example, referred to in the current statutory guidance as well as the Careers & Enterprise Company recommendations. Schools and colleges in the North East LEP area are also piloting a new national careers guidance framework based on the benchmarks.[3.49] The DfE's December 2017 careers strategy has built on the work from that pilot and government will fund 20 careers hubs supported by a coordinator from the Careers and Enterprise Company.

Wales has seen a similar pattern in the development of its quality standard. In 2002, a single, national award was launched to replace local awards, called the Careers Wales Mark. Neither Scotland nor Northern Ireland have a quality award for careers provision.[3.50] However, the Scottish government has launched a Career Education Standard that sets out an entitlement and recommended learning outcomes for young people and clear expectations of schools, colleges and their partners, and licensed awarding bodies in England are to accredit schools in Northern Ireland.

In total, over 1,100 schools, colleges and other providers have achieved accreditation or are working towards achieving an award in England. There is some evidence to suggest that schools that have gained awards have also improved attainment and reduced their levels of absence.

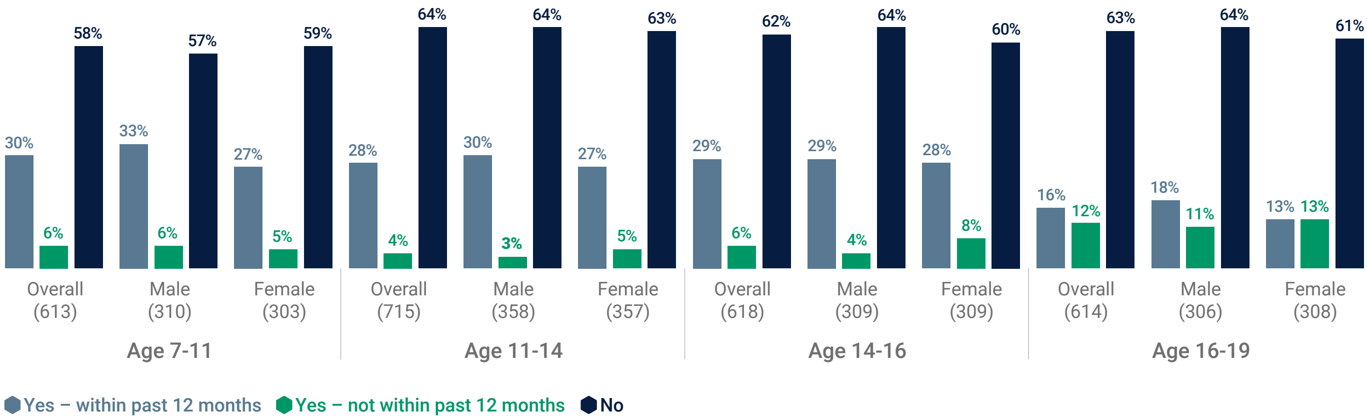
Figure 3.18 The eight 'Gatsby benchmarks'

		The benchmarks
1	**A stable careers programme**	Every school and college should have an embedded programme of career education and guidance that is known and understood by students, parents, teachers, governors and employers.
2	**Learning from career and labour market information**	Every student, and their parents, should have access to good quality information about future study options and labour market opportunities. They will need the support of an informed adviser to make best use of available information.
3	**Addressing the needs of each student**	Students have different career guidance needs at different stages. Opportunities for advice and support need to be tailored to the needs of each student. A school's careers programme should embed equality and diversity considerations throughout.
4	**Linking curriculum learning to careers**	All teachers should link curriculum learning with careers. STEM subject teachers should highlight the relevance of STEM subjects for a wider range of future career paths.
5	**Encounters with employers and employees**	Every student should have multiple opportunities to learn from employers about work, employment and the skills that are valued in the workplace. This can be through a range of enrichment activities including visiting speakers, mentoring and enterprise schemes.
6	**Experiences of workplaces**	Every student should have first-hand experience of the workplace through work visits, work shadowing and/or work experience to help their exploration of career opportunities, and expand their networks.
7	**Encounters with further and higher education**	All students should understand the full range of learning opportunities that are available to them. This includes both academic and vocational routes and learning in schools, colleges, universities and in the workplace.
8	**Personal guidance**	Every student should have opportunities for guidance interviews with a career adviser, who could be internal (a member of school staff) or external, provided they are trained to an appropriate level. These should be available whenever significant study or career choices are being made. They should be expected for all students but should be timed to meet their individual needs.

Source: Gatsby Charitable Foundation, 2014

3.47 Quality in Careers Consortium Board. 'The Quality in Careers Standard and Quality Awards for CEIAG in England', March 2017.
3.48 Gatsby Charitable Foundation. 'Good career guidance', 2014.
3.49 The North East Local Enterprise Partnership. North East schools and colleges selected for national careers pilot, October 2015.
3.50 Eg Career Development Institute. Quality assurance of career education and IAG in schools and colleges; Education Scotland, Skills Development Scotland & Smarter Scotland. Developing the Young Workforce: Career Education Standard (3-18), September 2015.

Figure 3.19 Young people between age 11 and 19 who recall taking part in a STEM careers activity (2017) – UK



Source: EngineeringUK, EBM 2017

Inspiration activities and enrichment

The ASPIRES project has established that most young people enjoy studying science when they start secondary school and are positive about science outside school. To sustain this interest through school and beyond, ASPIRES recommends that STEM providers:

- focus on the message that science is useful for any career
- challenge the 'brainy' image of science, and especially physics
- build young people's 'science capital' (science-related knowledge, understanding, attitudes, behaviours and social contacts)
- challenge the white, male, middle-class image of science[3.51]

Promisingly, the results from the 2017 EBM suggest that the proportion of school-age children who have taken part in a STEM careers activity is rising. Among primary age children, this figure was 30%, with the majority participating in a STEM activity in the last year (**Figure 3.19**). These proportions were somewhat lower among secondary age pupils, varying from 29% at age 14 to 16, to 16% of 16 to 19 year olds. This suggests that around 26% of pupils are being reached with some kind of activity annually. The EBM from the previous year also found nearly half of teachers surveyed had taken part in such an activity at some point.

The sheer number and range of inspiration and engagement activities, within what has essentially become a competitive market, can make it difficult for schools to identify the most appropriate and impactful activities for their setting.

However, the sheer number and range of inspiration and engagement activities, within what has essentially become a competitive market, presents difficulties for schools. They often struggle to differentiate between them and identify the activities that would be most appropriate and impactful in their setting. The Royal Academy of Engineering (RAEng) estimates that more than 600 UK organisations run initiatives designed to engage schools with STEM.[3.52] Many of these are specialist education enrichment providers but others include professional bodies, subject associations, science centres and charitable ventures. Individual universities and employers are also active. The RAEng UK STEM Education Landscape report states that most of this provision is targeted at 11 to 14 year olds in the form of 'talks and presentations' on a particular aspect of STEM, or hands-on extra-curricular activities.

Perhaps the most widely available activity for young people is a school science club (or STEM club). At least 3,000 STEM clubs are thought to exist in the UK, on the basis of those affiliated to national networks.[3.53] These offer school-age children opportunities to explore science, technology or engineering in an informal setting, in lunch breaks or after school. Typically, they provide pupils with opportunities to work on exploratory projects in teams and enter competitions. Many clubs have access to specialist scientific equipment and some work with local STEM employers. STEM Learning helps teachers and others form and run these clubs through its STEM Club network, which provides quality-assured resources and support.

EngineeringUK and the RAEng are working together on co-ordination and evaluation of activities that promote engineering. Tomorrow's Engineers is a programme of co-ordinated schools outreach and careers inspiration, led by engineering businesses, not-for-profit organisations and charities.[3.54] Its aim is to provide all young people aged 11 to 14 with the opportunity to access at least one engineering experience with an employer, to help them make the connection between school work and career possibilities. EngineeringUK is also creating a 'heat map' of engineering careers activities across the country through a national database that captures employer outreach activity. Many

3.51 King's College London. 'ASPIRES 2 responds to inquiry on science communication', June 2016.
3.52 Royal Academy of Engineering. 'The UK STEM Education Landscape', May 2016.
3.53 STEM Learning. 'STEM Clubs'.
3.54 Tomorrow's Engineers, 2017.

companies and organisations working with schools are sharing data on their activities to build a picture of current school coverage. This understanding will enable Tomorrow's Engineers to identify areas of need and opportunity and also reduce competition and duplication. This should result in employers in the network reaching more local schools more efficiently.

According to the RaEng, there is "a key issue with regards to ascertaining the efficacy of 'single-activity' interventions compared with longer-term, sustained interventions, in terms of increasing attainment and progression to STEM education study in post-16 education."

Impact of inspiration activities

While STEM inspiration and enrichment activities are extremely widespread, their impact in relation to take-up of subjects post-16 (and ultimately increasing the flow of skills into the engineering workforce) is less certain. In its review of the STEM education landscape, RAEng noted that some of the most common activities are the least well evaluated. Where evaluation does take place, it is often limited to a brief feedback form filled out by students or teachers directly after the activity. It concluded that there is "a key issue with regards to ascertaining the efficacy of 'single-activity' interventions compared with longer-term, sustained interventions, in terms of increasing attainment and progression to STEM education study in post-16 education."[3.55]

This chimes with the view of Sheffield Hallam University's Science and Innovation Observatory, which has stated that the potential for learning from existing evaluations of STEM activities is very limited.[3.56] More recently, Banerjee has conducted a longitudinal national evaluation of STEM 'enrichment and enhancement activities'. This was based on pupil-level data from 600,000 year 7 pupils in English state secondary schools in 2007, and tracked which pupils went on to take STEM subjects post-16. The proportions of pupils who studied STEM A levels were very similar, whether or not their records suggested they had undertaken STEM enrichment activities. One key difference was that pupils who took part in STEM enrichment activities in key stage 3 were more likely to take STEM subjects post-16 than those who took part in activities in key stage 4. This supports the view that ages 11 to 14 are potentially key to inspiration. However, Banerjee's conclusion was: "While these enrichment and engagement activities may have been enjoyable and memorable for children, there is no evidence they encouraged them to keep on studying STEM subjects." Nor was there any evidence that these activities increased the numbers of children from poorer homes or from ethnic minority backgrounds who studied STEM subjects post 16.[3.57]

It is possible that the positive effects of some enrichment activities covered by the study were balanced out by lesser effects from others, making the overall impact appear negligible. More granular recording of activities would be needed to distinguish between different STEM activities in more detail.

Post-event surveys of 11 to 14 year olds who attended The Big Bang UK Fair,[3.58] and of the more general population of this age,[3.59] reveals some short-term differences in attitudes:

- 75% of attendees had positive perceptions of engineering, compared with 47% in the general population
- 58% of attendees said they know what people who work in engineering do, compared with 30% overall (with a bigger difference in the case of girls: 56% compared with 20%)
- 61% of attendees agreed that a career in engineering is desirable, compared with 43% in the general population (girls: 55% compared with 30%)

Teachers involved in STEM Clubs reported improvements in their confidence in teaching, their subject knowledge and proficiency in teaching it, and links with STEM employers.

However, what is more important is whether attitudinal differences are sustained in the longer term. The 2017 EBM research reveals that pupils who had attended STEM careers activities were more likely to want to be an engineer (43%) than those who had not (21%). The difference was higher for those who had attended an activity within the last year, but largely dissipated among those who had taken part more than a year ago. This seems to suggest that sustained, periodic episodes of inspirational activity may be necessary for optimum impact.

An evaluation of STEM Clubs suggests that being actively involved can have an impact on a young person's interest and engagement in studying STEM subjects at school and beyond, and open their eyes to a career in STEM.[3.60] Teachers report that young participants' enjoyment of STEM Club impacts positively on their attainment and progress in STEM subjects, and on their perceptions of their ability in these subjects. Both aspects increase the likelihood of them pursuing STEM subjects post-16 and STEM-related careers. The evaluation also shows that teachers and others involved in STEM Clubs

3.55 Royal Academy of Engineering. 'The UK STEM Education Landscape', May 2016.
3.56 Sheffield Hallam University. 'Are STEM evaluations making a difference - and can we make them work better? Science and Innovation Observatory Policy and Strategy Briefing Paper', Evaluating STEM initiatives, 2011.
3.57 Banerjee, P. A. 'Is informal education the answer to increasing and widening participation in STEM education? Review of Education', June 2017.
3.58 IFF Research. 'EngineeringUK Evaluation - Big Bang Fair 2016 Report', for Big Bang Education CIC, July 2016.
3.59 IFF Research. 'Engineers and Engineering Brand Monitor 2015', September 2015.
3.60 STEM Learning. 'STEM Clubs – Making an impact 2016-17', 2017.

improve their confidence in teaching, deepen and increase their subject knowledge and proficiency in teaching it, and can forge links with STEM employers. It should, however, be stressed that this was a relatively short-term evaluation, and its findings principally relied on teachers' attitudes and perceptions. As with many evaluations, there was no opportunity to use more robust measures such as tracking those who joined STEM Clubs and their subsequent subject choices.

Given the amount of effort and resources that are currently going into delivering STEM inspiration and enrichment initiatives, there is an urgent need to identify which activities work and which don't, so that schools can choose wisely. This will necessitate tougher evaluation, which will only be feasible if it is underpinned by more systematic recording of the activities that pupils take part in while at school.

Employer engagement

Employers have a crucial role to play in the future of careers provision. English statutory guidance makes that clear: the 2011 Education Act moves away from an emphasis on careers education and guidance delivered by careers professionals or schools, and towards a reliance on business for the same advice. The inclusion of the word 'enterprise' in the name of the Careers & Enterprise Company, set up by the Cameron government to improve careers provision, underscores the policy direction. In the other nations of the UK the mood is similar: the careers provision strategies for Wales, Scotland and Northern Ireland highlight the potential offered by partnering with employers.

The key reason to involve employers in these aspects of education is that their involvement is thought to make young people more ready for work. As the number of young unemployed is a widely reported national metric, the opportunity to reduce the likelihood of young people failing to progress into employment or training is compelling. Employer engagement is also seen as a tool to influence young people's career aspirations. For policymakers, this aspect is a highly attractive alternative to professional careers provision, especially if the effectiveness of that provision is in doubt. There is therefore currently huge emphasis on employer engagement, not only to make young people more employable but to fill the current gap in careers provision.

The rising demand for employer engagement in schools also responds to two trends in the youth labour market. One is the evolving requirements of employers, who increasingly require new recruits to have experience of the workplace.[3.61] Both the Wakeham and Shadbolt Reviews reinforced the importance of graduates having had experiences of work, to improve their employability and to enable them to transition successfully into the workforce.[3.62, 3.63] The UK Commission for Employment and Skills (UKCES) also found that work experience is a critical or significant factor for two thirds of employers – often more important than a candidate's level of academic attainment or vocational qualifications.[3.64]

Both the Wakeham and Shadbolt Reviews reinforced the importance of graduates having work experience to improve their employability and to enable them to transition successfully into the workforce.

The second trend is the decline in popularity of part time work amongst teenagers (ie the 'Saturday job'). The City & Guilds *Great Expectations* [3.65] survey found that a quarter of 14 to 19 year olds had no workplace experience at all and only a quarter had any paid work experience (part time, vacation or casual work). The remaining half had only completed a short work experience placement arranged through school or college. This trend is likely to worsen given the removal in the 2011 Education Act of the statutory duty for schools to provide work-related learning, which in practice was often a 'compulsory' short period of work experience. There has, however, been recent emphasis from the Department for Education on work experience for those who study vocational qualifications, and it is sure to be a key element of the new technical education pathways being developed.

The convergence of these two trends risks young people being caught in a Catch-22: it is difficult to find work without experience and difficult to obtain experience without finding work. There is also a STEM angle: the ASPIRES research has found that 15 to 16 year olds aspiring to STEM careers were among those least likely to have had work experience,[3.66] and a study by CRAC, the career development organisation, suggested that work experience is harder to find in STEM industries than other industries.[3.67]

In terms of social mobility, it is widely acknowledged that the removal of statutory work experience (and funding for it) has led to placements increasingly being organised by parents and families rather than by schools or agencies. As a result, pupils from socially advantaged families are more likely to find higher-quality work experience than those without that social capital.[3.68]

For a multitude of reasons, then, employer engagement is set to remain a key element of education and skills policy, so the nature and effectiveness of such engagement merits further investigation.

Two thirds of employers state work experience as a critical factor for recruitment – often more important than a candidate's academic attainment or vocational qualifications.

3.61 Pearson/CBI. 'Helping the UK thrive – CBI/Pearson Education and Skills Survey 2017', July 2017.
3.62 BIS and HEFCE. 'STEM Degree Provision and Graduate Employability: Wakeham Review', May 2016.
3.63 BIS. 'Shadbolt Review of Computer Sciences Degree Accreditation and Graduate Employability', May 2016.
3.64 UKCES. 'Catch 16-24. Youth Employment Challenge', February 2015.
3.65 The City and Guilds of London Institute. 'Great Expectations: Teenagers' aspirations versus the reality of the job market', 2015.
3.66 King's College London. 'ASPIRES 2 Project Spotlight: Year 11 Students' Views of Careers Education and Work Experience', February 2016.
3.67 The Science Council. 'Work experience for STEM students and graduates', April 2011.
3.68 Social Mobility Commission. 'Time For Change: An Assessment of Government Policies on Social Mobility 1997-2017', June 2017.

Engagement in practice

Employer engagement is changing, with the range of activity widening as well as its extent. The CBI reports that 4 out of 5 of its member businesses have at least some links with schools and/or colleges.[3.69] These are mostly with secondary schools and FE colleges, an increasing number of which are getting involved at this level. More primary schools are forging links with business too, although numbers are still small. The leading areas of support for primary schools are providing talks to inspire pupils about opportunities in working life and encouraging interest in certain subjects, including STEM.

Most of the employers with links to secondary schools support them in careers provision activities, including giving talks to pupils. Around 80% of employers in the CBI survey offer work experience to school-age young people in their local area through 1 or 2 week placements.

The CBI survey results also suggest that three quarters of their member businesses would be willing to expand their career-related activities in schools and colleges if certain barriers were removed: reluctance from local schools or their pupils to engage, and fears over whether the employers can offer work activities that are worthwhile for young people.

Many employers and schools see work placements primarily as a means of improving employability skills or work readiness (particularly at age 14 to 16). They persist with a standalone week- or fortnight-long placement model. However, others view work experience as part of overall career development. This has led to more flexible and personalised models for gaining workplace experience, which may involve less time physically at a single employer's premises. For example, Education Scotland's guidance on placements emphasises a range of possible models: "a number of bite-size placements through to extended placements… within the conventional school week or outwith it."[3.70]

London Ambitions, likewise, is an advocate for a flexible model and is calling for local authorities and schools to facilitate 100 hours experience of the world of work for every young Londoner. These experiences could include talks by industry experts, work tasters, coaching/mentoring, enterprise activities, part time work, careers fairs, work shadowing or work experience. Crucially, it states that the experiences should be recorded in a personalised digital portfolio. [3.71]

In recent years, the number of people in business giving talks and taking part in extra-curricular activities in schools as part of employer engagement has also grown substantially. The long-established STEM Ambassadors scheme has grown to over 30,000 individuals from 2,500 different organisations, who are available to schools and others seeking support in their delivery of STEM activities.[3.72] The scheme was facilitated locally by STEMNET organisations but more recently has been coordinated nationally by STEM Learning at York.

Case study – Digital badges for STEM learning

Brenda Yearsley, UK Schools and Education Manager, Siemens

Digital badges enable learners to capture and evidence valuable learning that takes place outside formal qualifications. Siemens digital badges are learning 'missions' built with open badge technology (open technical standards created by the Mozilla Foundation), based on real world applications of engineering and science. These 'missions' might be attempted within a classroom lesson or in an extra-curricular activity. Siemens digital badges are free to use, based on Siemens' award- winning STEM education portal resources from key stage 2 to 4. Digital badges help teachers reward and recognise pupils' STEM learning and skills. Hosted on open platforms makewav.es and Open Badge Academy, they allow learners from any background to interact directly with future employers like Siemens, supporting pathways from school to further and higher education and into jobs and careers.

"Siemens Digital badges are a great way of recognising achievements by students from a wide range of backgrounds. They present challenges that are authentic and value approaches from diverse ways of thinking and working. The digital format makes them easy to administer and appealing to students." – *Edmund Walsh, Educationalist/Science Specialist, Science Learning Centre*

"Siemens has designed a differentiated pathway of badges to promote engineering careers: supporting students at primary school to spark an interest and passion in STEM subjects, whilst enabling students at secondary school to find out more about the different careers available and what it takes to work in the industry." – *Lucy Lewis, Digitalme (City and Guilds group) and Matt Rogers, Education Programme Manager/Primary Teacher*

Learn more www.siemens.co.uk/digitalbadges

3.69 Pearson/CBI. 'Helping the UK thrive – CBI/Pearson Education and Skills Survey 2017,' July 2017.
3.70 Education Scotland & Smarter Scotland. 'Developing the Young Workforce: Work Placements Standard', September 2015, p4.
3.71 London Enterprise Panel, London Councils and Mayor of London. 'London Ambitions: Shaping a successful careers offer for all young Londoners', June 2015.
3.72 STEM Learning. 'STEM Ambassadors'.

In 2011, the Education and Employers charity, which was founded in 2009 to develop more partnerships between schools and colleges with employers, also launched Inspiring the Future, a network of speakers at all levels across all industrial sectors who pledge an hour of their time per year to give a talk in a state school. The network enables schools to access the database and invite an appropriate local speaker, who then gives a talk in school about what they do at work and how they reached that position. Inspiring the Future was launched with government support as a response to the Department for Education's position that talks by business people would be more effective in young people's career development than support from careers professionals. This scheme appears to be widely used, with Education and Employers reporting in 2016 that 5,500 schools had engaged with it.[3.73] Its database currently includes over 37,000 volunteers and 11,000 teachers. It has subsequently extended the volunteer offer to include support for schools running mock interview sessions and mentoring, as well as curricular support in developing reading and numeracy skills.

Speakers for Schools, a broadly similar venture launched in 2011, offers state schools and colleges access to 'eminent figures in their field' for inspirational talks during school assemblies. Although operating at a smaller scale than Inspiring the Future, the scheme has over 1,000 speakers and has worked with around 2,000 schools.[3.74] It is funded by the Law Family Charitable Foundation and has been fronted since it's launch by Robert Peston, the journalist and presenter.

Several other schemes exist which aim to provide similar 'encounters' of this type with businesses, including Founders4Schools. This was also launched in 2011 and focuses on 'local business leaders' and school alumni as speakers. It is now supported by the Careers & Enterprise Company. SchoolSpeakers slightly predates these other schemes and offers a wider range of encounters with business people, but levies a charge on the school for its service. All of these schemes make reference to the importance of inspiring young people about STEM careers.

The 4 generic schemes named here are in addition to numerous sector-based initiatives that offer 'inspirational' speakers to schools to promote particular career sectors (of which STEM Ambassadors is the largest), and programmes offered directly by employers. While their existence is encouraging, the proliferation of schemes with similar aims demonstrates how marketised and unplanned this type of support for schools is, particularly in England. As previously stated, it is possible schools may find it hard to differentiate between all these offers.

Alongside speakers, one area of current growth in employer engagement is the mentoring of young people by employers' staff. Mentoring is a sustained relationship between an employer (through an employee) and a young person, which focuses on personal or career development. This can help to young people to stay engaged in education, inspire and motivate them, and provide them with meaningful encounters with the world of work.

Until 2011, England had a government-funded network of Education Business Partnerships that acted as intermediaries and fostered links between schools and employers, to support work experience and what was then known as the 'enterprise agenda'. The funding for these was removed by the coalition government and the majority closed down. The Careers & Enterprise Company is effectively now trying to fill that gap, look to appoint a paid enterprise adviser in every Local Enterprise Partnership (LEP) and a volunteer enterprise coordinator from business in every school, to provide some coordination in this market. It is also trying to increase provision in areas that currently have little access to this type of support from employers, by funding some providers to extend their work to those 'cold spots'.

Case study – Coding to engage students

Tim King, Senior Technical Advisor, Cummins

The Engineering team at Cummins Daventry has developed an exciting introduction to coding for students at their local partner schools who have no previous experience or awareness of this growing facet of engineering.

It starts with the team completing a task manually, with a simple sequence of instructions being read out in order and each team member being assigned a separate task: reading, operating a stop watch and operating a switch resulting in the group turning a light on and off. This series of instructions is then reproduced in simple blocks of code in Python using a Raspberry Pi, with the original circuit being modified to enable the same operation to be completed, but this time with the computer controlling the actions.

This approach is then developed to give instructions to a programmable model mine truck - a small scale version of one of the impressive applications of Cummins Daventry products. It uses the same code structure but this time activates appropriate motors for a period of time to operate the truck.

The students go on to compete in small teams, giving instructions to control the truck around a course and tip toy bricks onto a target area – the winners being the team who tip the most bricks.

Through its development over the last 2 years, the inclusive nature of this project has given both accessibility and a good awareness of coding to a broad and diverse range of young pupils. In addition to this, the approach has proven ideal in stimulating an interest in students with a wide spectrum of learning styles - from the academically-gifted and talented to those who benefit from more a practically-oriented education.

3.73 Education and Employers. 'Inspiring the Future four year review 2012-2016', August 2016
3.74 Speakers for Schools. 'Year in Review 2015/16: Five Year Anniversary', November 2016.

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Education and Employers also acts as a taskforce, aiming to improve the quantity, quality and relevance of employer engagement by conducting through research and sharing good practice. Its evidence shows that practical employer engagement is on the rise: young adults surveyed in 2016 recalled an average 1.6 school-mediated engagements with employers while at school, which was 22% higher than 2011.[3.75]

Lord Young has championed the importance of young people recording their enterprise-related activities in a 'digital passport'. The Careers & Enterprise Company has widened this concept to include other activities outside school that could contribute to career development, and is carrying out early trials on how such a 'Passport for Life' could be implemented.

Case study – Evaluating long term impact of engagement

Carol Davenport, Director of NUSTEM, Northumbria University

Through its NUSTEM initiative, Northumbria University in Newcastle works with children and young people from across the north east of England to increase the number and diversity of those choosing a STEM career. NUSTEM aims to achieve this by building up the science capital of children and their key influencers: their families and teachers.

Working closely with 30 partner schools, NUSTEM interacts with children and families from pre-school to post-16. A key part of achieving this aim is to develop long-term links with schools and the children and families within them. NUSTEM runs hands-on family workshops in schools and communities, in which children and parents/carers work together to find out about science or solve engineering problems. In doing so, families talk about science and STEM with each other: one aspect of science capital.

Other elements of NUSTEM's approach include career-inspired curriculum linked workshops; close coordination and support with primary science coordinators and secondary careers and science leads; whole-school CPD; and resource production to support teachers to embed careers in the curriculum.

NUSTEM is using a mixed-methods research approach to evaluate the longer-term impact of this sustained schools work. We have developed a set of tools that can be used with primary- and secondary-aged children to evaluate changes over time in aspects of science capital. This data, along with an analysis of examination subjects from the National Pupil Database, will enable us to evaluate the impact of sustained and ongoing interactions over many years.

By integrating research with carefully-targeted interventions over the long term, NUSTEM aims to offer practical advice and evidence of impact to the wider HE and STEM sectors.

www.nustem.uk

Case study – Inspiring a new generation of engineers

Dr Ajay Sharman Regional Network Lead London & South East, STEM Learning

STEM Ambassadors are volunteers from a wide range of science, technology, engineering and mathematics (STEM) related jobs and disciplines across the UK. They are an invaluable, free resource for young learners, teachers and other individuals working with young people. In the engineering sector, 20,000 STEM Ambassadors help young people make well-informed choices, as well as promoting positive images of the industry. Professional engineering institutions (PEIs) often actively encourage their members to take part in the scheme, and many STEM Ambassadors are members of PEIs such as CIHT, ICE, IChemE, IET, IMechE, and IOP.

Dale Power Solutions, one of the UK's leading providers of secure power service and solutions, actively encourages its employees - particularly apprentices - to become STEM Ambassadors. The company recognises multiple benefits of engaging with the programme, in terms of recruitment and staff development. As they explain, "We are based in Scarborough - people don't tend to pass through this area very often. This means we need to recruit our apprentices locally, so it is important for us to be part of our community and give something back."

Independent evaluation demonstrates the positive impact that STEM Ambassador activities have on young people, employers, teachers and STEM Ambassadors themselves. Ninety per cent of young people who engage with STEM Ambassadors say that it increases their engagement with STEM, helping them to make informed decisions about their future careers. With volunteers from a vast range of engineering professions, they are helping to drive the aspirations of the next generation and increase the talent pipeline across the industry.

As far as the STEM pipeline is concerned, there is clearly an opportunity for the STEM community to harness the current policy momentum that exists around employer engagement. Promoting engagement by STEM employers will have a dual effect in providing both generic and more specific STEM-related inspiration to young people. In reality, as the range of engagement by employers broadens, the boundary between STEM inspiration or enrichment activities and encounters with employers will becomes increasingly blurred.

Impact of employer engagement

The Careers & Enterprise Company and Education and Employers Taskforce are currently developing the evidence base for the quality and impact of encounters between employers and young people in schools. As shown earlier in Figure 3.17, employer mentoring and enterprise competitions are regarded as well-established and impactful types of engagement. Careers talks by business people, and enterprise activities and employability skills workshops facilitated by employers are less robustly established in terms of impact.[3.76]

3.75 Education and Employers. 'Contemporary transitions: Young Britons reflect on life after secondary school and college, Occasional Research Paper 11', June 2017.
3.76 Careers & Enterprise Company. 'What Works in Careers and Enterprise?' December 2016.

EngineeringUK's 2016 report featured research by the Education and Employers Taskforce showing a positive correlation between careers talks given by employers that young people had attended at school in the 1980s and their subsequent earnings when aged 26. The study found an increase in subsequent earnings for each careers talk attended when they were 14 to 15 years old, but much less impact for talks attended if they were older.[3.77] The Taskforce has similarly found that adults who have had 4 or more interactions with employers while in school were 5 times less likely to be 'NEET' (not in education, employment or training) than those who did not recall such activities.[3.78] Such findings have underpinned the strategy of the Careers & Enterprise Company in trying to increase the number of encounters that young people have with employers.

A smaller but international study of STEM-related outreach activities provides a complementary view, as the activities it investigated were facilitated by employers. This found that participation in engaging extra-curricular activities increased students' intrinsic motivation to pursue STEM subjects.[3.79] This clearly conflicts with the findings of Banerjee related in the previous section, and reinforces the need for more robust research into the impact of more tightly-defined STEM activities.

Adults who have had four or more interactions with employers while in school were five times less likely to be 'NEET' than those who did not recall such activities.

The Careers & Enterprise Company believes there is a wide range of evidence that mentoring by employers can have a significant and observable impact on young people, as well as on the mentors and their employers. A meta-analysis suggests that school-based employer mentoring has a small but significant positive effect. The positive outcomes for young people included improvements in behaviour and engagement and, to a lesser extent, attainment and progression.[3.80]

The evidence base for the value of work experience is somewhat longer established. Research on the impact of work experience by the Education and Employers Taskforce for the Edge Foundation has shown that students aged 16 to 17 who have had part -time work are more likely to be in work at age 18 to 19, and are also less likely to be NEET 5 years later.[3.81,3.82] In a recent study for the Department for Education, young people, their schools and colleges identified multiple benefits of work experience, particularly in developing employability skills and increasing confidence.[3.83] However, this study did rely on respondents' perceptions of impact rather than hard evidence.

Interventions by professional engineering institutions

Many engineering institutes organise competitions to give students the opportunity to research, design and make prototype solutions to genuinely tough engineering problems – and ultimately, to inspire them to consider a career in engineering.

The **Institution of Engineering and Technology (IET)**, for example, has introduced a Faraday Challenge, which is an engineering-based competition for students aged 12-13. The challenge is all about letting the students be creative and use their own problem-solving skills to explore their capabilities as engineers. The winners of Faraday Challenge Days are awarded a prize for each team member and a trophy for their school. The top teams from across the UK will be invited to showcase their ideas at an event at the end of the season.

The **Institution of Agricultural Engineers (IAgre)** has run a range of inspiration activities, including a Young Engineers' Competition for students in both secondary school and further education. In 2017, students were asked to manufacture a remote or radio controlled vehicle that could tackle the competition track with a given set of wheels, battery and maximum dimensions. The aim was to make the event both entertaining and educational, and raise the awareness among young engineers of the scope and vibrancy of the industry.

More information on these events can be found at:

www.faraday-secondary.theiet.org/faraday-challenge-days/

www.iagre.org/youngengineers

Engineering institutions such as the **Institution of Civil Engineers (ICE), Institution of Structural Engineers (IStructE), Institution of Engineering and Technology (IET) and Institution of Mechanical Engineers (IMechE)** provide guidance, advice and support for those who want to start or develop a career in engineering. Aimed at young people, these resources provide advice on what subjects they should choose when taking A levels, and what type of apprenticeship or vocational qualification is best when considering a career in a specific discipline. A range of resources, including case studies and video links, are also available to demonstrate what engineers within certain disciplines do in practice, to give deeper insight into engineering careers.

Resources are also available to support teachers in providing careers guidance. IET, ICE, IMechE and IStructE run an education service aimed at supporting teachers of science and technology and provides a range of curriculum support, resources and information for schools. They support partnership organisations in the provision of STEM resources and experiences for both teachers and students across the UK.

More information on these resources can be found at:

www.ice.org.uk/careers-and-training/graduate-civil-engineers/how-to-become-professionally-qualified

www.istructe.org/education-and-careers/how-to-become-a-structural-engineer

www.imeche.org/careers-education/careers-information

www.theiet.org/resources/teachers/index.cfm

3.77 Kashefpakdel, E. and Percy, C. 'Career education that works: an economic analysis using the British Cohort Study, Journal of Education and Work', April 2016.
3.78 Education and Employers. 'It's Who You Meet: Why Employer Contacts at School Make a Difference to the Employment Prospects of Young Adults', February 2012.
3.79 Vennix, J. et al. 'Perceptions of STEM-based outreach learning activities in secondary education, Learning Environments Research', April 2017.
3.80 The Careers & Enterprise Company. 'Effective employer mentoring. Lessons from the evidence', July 2016.
3.81 Education and Employers. 'Profound employer engagement in education: What it is and options for scaling it up', October 2013.
3.82 Department for Work and Pensions. 'Work experience: a quantitative impact assessment', March 2016.
3.83 DfE. 'Work experience and related activities in schools and colleges', March 2017.

3.7 – Diversity issues

Gender

The diminishing representation of girls and women with progression along the STEM skills pipeline is well known. As described in detail later in this report, while there is broad gender parity in much of school study up to age 16, only 27% of girls' entries to A levels in 2017 are in STEM subjects, whereas these subjects make up around 46% of boys' entries. Further, only 21.5% of A level physics students are girls (**Figure 3.20**).[3.84] Strikingly, this proportion has not varied much in the last 30 years, despite repeated efforts to increase it.

Figure 3.20 A level physics entrants by gender (2017) – UK

Source: JCQ, 2017

This is also the case in higher education, even though female students are in the majority at UK universities and attain higher average degree grades than male students. Women make up only 16% of first degree students in engineering, although they are better represented in certain engineering disciplines at first degree and postgraduate level.

Recent research found that 29% of male teachers felt STEM careers were more for boys than girls.

Transitions into employment are other points of 'leakage' in the pipeline that ultimately contribute to the proportion of female professional engineers in the workforce being lower than 1 in 10.[3.85] Gender segregation appears to be particularly acute among school-leavers taking up apprenticeships. The government's *Post-16 skills plan*, which laid out its ideas for technical education in England, pointed out that nearly 9,000 level 2 apprenticeships in hairdressing were started by women in 2013/14, while only 80 started at this level in engineering.[3.86]

Only 21.5% of A level physics entrants – and just 16.0% first degree undergraduates studying engineering and technology – were female.

Gender stereotyping

Research funded by Microsoft across Europe suggests that girls are attracted to STEM subjects and careers up to the ages of 11 to 12, but by 15 to 16 that interest has dropped off for many and is very hard to recover.[3.87] This is further confirmation of the importance of interventions in primary school and the early years of secondary school, to encourage young people, particularly girls, to continue to STEM education. The Institute of Physics (IoP) has been at the forefront of initiatives to encourage a greater proportion to girls to pursue physics at A level.[3.88] Research by the IoP and in the ASPIRES project has found two key issues in relation to choosing physics post-16:

- it is presented as a subject for men (through the current lack of representation of women as well as its portrayal in popular media)
- it is seen as a 'hard' subject – and 'hard' subjects tend to be seen as 'for men'.[3.89]

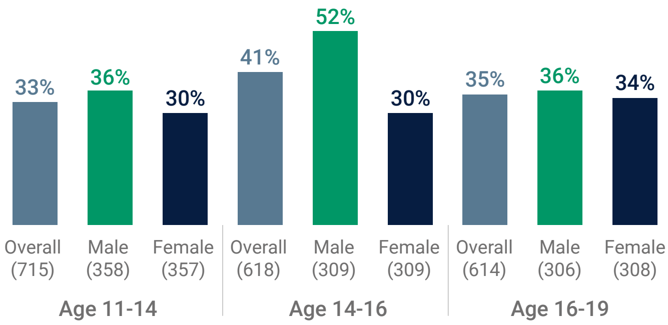
These issues may underlie fears expressed by some girls of not wanting to continue with physics post-16 because they do not want to be 'the only girl in the class'. Gender differences may also arise if post-16 choices are driven by career thinking: the EBM research indicates that fewer girls consider engineering careers than boys of a similar age (**Figure 3.8**). This type of stereotyping is not necessarily countered by advice from teachers, as recent research has suggested that 29% of male teachers think STEM careers are more for boys than girls.[3.90] The same view was held by 16% of female teachers. The IoP believes it may be necessary to change the environment at a whole-school level to adjust these negative influences on such a key subject choice.[3.91]

Our EBM results show the persistence of gendered attitudes towards engineering careers by parents/guardians. This can relate both to the gender of the parent and to the gender of their children. For example, EBM 2016 showed that female parents were less likely than male parents to say they would recommend an engineering career to their children (67% compared to 85%). Worryingly, that difference was greater in relation to female children than male. Evidence in the Perkins Review similarly indicated that parents of boys were significantly more likely to want their child to pursue an engineering career than parents of girls.[3.92]

Gender stereotyping also applies in relation to apprenticeships in the engineering context. The latest EBM results suggest that around a third of teenage pupils see being an apprentice as desirable, but this is higher among male than female pupils in the 11 to 16 range, and particularly among 14 to 16 year olds (**Figure 3.21**). Overall, parents were somewhat more likely to perceive being an apprentice as desirable for their child (just over 45%) than the pupils themselves.

3.84 JCQ. 'A and AS Level Results', Summer 2017, 2017.
3.85 Royal Academy of Engineering. 'Increasing diversity and inclusion in engineering – a case study toolkit, Diversity Leadership Group', 2015.
3.86 DfE and BEIS. 'Post-16 skills plan and independent report on technical education', July 2016.
3.87 Microsoft. 'Why Europe's girls aren't studying STEM', 2017.
3.88 Engineering UK. 'The state of engineering 2017', January 2017.
3.89 Archer L. & J. DeWitt, 'Understanding Young People's Science Aspirations, Routledge', 2017.
3.90 British Gas and Catherine O'Kelly. 'Teachers desperately need support from Britain's businesses to close the STEM skills gap', August 2017.
3.91 Institute of Physics. 'Opening doors - A guide to good practice in countering gender stereotyping in schools', October 2015.
3.92 Department for Business, Innovation & Skills. 'Professor John Perkins' Review of Engineering Skills', November 2013.

Figure 3.21 Proportion of 11 to 19 year olds who think being an apprentice is desirable (2017) – UK



Source: EngineeringUK, EBM 2017
Proportions relate to those who gave a score of 4+ (on the 5-point scale) for the question, 'How desirable do you believe being an apprentice is?', with 1 being 'not at all desirable' and 5 being 'very desirable.'

Ethnicity

There is increasing interest in identifying and investigating under-representation among other groups, including ethnic minorities. These are areas where much more research and analysis are needed as they lack the significant evidence base that exists in relation to gender differences. What is known is that the key point of 'leakage' in the skills pipeline for those of minority ethnic background appears to occur at the transition to employment, rather than during subject choices. Chapters 7 and 8 show that 25% of engineering students are of BME origin – a higher percentage than in the general population of the same age range – yet they only account for 8% of the engineering workforce.

Some have suggested that the engineering sector needs to do more to understand the values and aspirations of different groups of younger people. Then it could align its vision and messages to resonate with a wider range of young people, so that a wider range see the profession as 'for people like me'.[3.93]

Tackling unequal participation

Current educational policy continues to focus on gender when it comes to tacking under-representation in STEM, partly because of its impact on the overall gender pay gap. In England, the Government Equalities Office has set a goal of 15,000 more entries by girls to mathematics and sciences by 2020 (around a 20% increase), to increase the flow into careers in what it considers well-paid industries.[3.94] Recent statutory guidance for schools on careers provision emphasises the benefit from exposing pupils to STEM employers, especially for female pupils: "[there is a] need to do this for girls, in particular, who are statistically much more likely than boys to risk limiting their careers by dropping STEM subjects at an early age." [3.95]

The Careers & Enterprise Company has made the proportion of STEM A levels taken by female students as one of its key measures when identifying the 'health' of current careers and enterprise provision.[3.96]

Some 'inspiration' activities which aim to enhance the interest of young people in STEM and engineering careers are being reviewed to identify their potential effectiveness among under-represented groups. It is increasingly recognised that some of the activities considered inspirational for boys may be less impactful for girls, and vice versa, so more nuanced approaches may be beneficial. The careers resources available from Tomorrow's Engineers have been reviewed with this in mind, and now present example careers in relation to their societal benefit, which is considered to appeal more strongly to female students.

In relation to ethnicity, the Royal Academy of Engineering has devised a range of actions to understand and remove barriers to diversity and inclusion, which include activities aimed at schools.[3.97] These include a project increasing the prominence of role models of BME background, and a good practice guide for recruiting female and BME apprentices. It also believes that the persistent image of science (especially physics) as subjects for the 'brainy' impacts particularly negatively on some minority ethnic students.

Further work in this area is recommended so that engineering can benefit from the increasingly diverse profile of young people in the UK, who constitute its future talent pool.

3.93 Institution of Mechanical Engineers. 'Big Ideas: The Future of Engineering in Schools', April 2016.
3.94 Government Equalities Office and The Rt Hon Nicky Morgan: 'Nowhere left to hide for gender inequality, press release', February 2016.
3.95 DfE. 'Careers guidance and inspiration in schools: Statutory guidance for governing bodies, school leaders and school staff', April 2017.
3.96 The Careers & Enterprise Company, 2017.
3.97 Royal Academy of Engineering. 'Diversity & inclusion in engineering.'

Case study – STEM outreach to increase female STEM participation

Nicola Swaney, Education Outreach Manager, Rolls-Royce

A strong future pipeline of well-qualified scientists and engineers is critical to the future success of the Rolls-Royce business. Rolls-Royce has a comprehensive STEM education programme aimed at inspiring people to study the STEM subjects, and helping to secure a future talent pipeline for the company and the wider industry.

Rolls-Royce has set a target to reach 6 million people by 2020 with its STEM education programmes and activities. The company has reached 2.8 million people so far, 47% of the target. In 2016, 1.2 million people were reached by the Rolls-Royce STEM programme, 68% of whom were actively engaged in STEM activities.

In the UK, there are over 1,200 Rolls-Royce STEM Ambassadors who are actively involved in the company's STEM education programme, which encompasses a wide range of activities including the Rolls-Royce Science Prize, the Big Bang UK Fair, Farnborough Air Show Innovation Zone, the Bloodhound Supersonic Car project, the Cub Scout Scientist Badge and Girlguiding's Brownie Science Investigator Badge.

Rolls-Royce has a particular focus on increasing the diversity of the company's talent pipeline and the company sponsors the National Engineering Competition for Girls, part of the Talent 2030 campaign that aims to achieve a 30% female engineering workforce by 2030. We work with Girlguiding to support the Brownie Science Investigator Badge. To gain the badge, Brownies (7 to 10 year old girls) must complete one activity from four sections designed to encourage investigative minds and an exploration of scientific principles. GirlGuiding will be launching a brand new programme in 2018 and Rolls-Royce is working with them to develop some great STEM activities and resources for all their members, from 5 to 25 years of age.

The company has a range of Employee Resource Groups including the UK Gender Diversity Network and the UK African and Caribbean professional Network that are active in the Rolls-Royce STEM programme.

Key messages from our Engineering Brand Monitor 2017

Since 2010, EngineeringUK has published the Engineering Brand Monitor (EBM), an annual survey into the perceptions, understanding and knowledge of the engineering community. The EBM helps us track progress on our mission to inspire tomorrow's engineers, as well as providing a national benchmark for the engineering community. The survey is carried out on our behalf by an independent research agency, which uses market research panels to collect responses. In 2017, over 2,000 young people aged 7 to 19 and roughly the same number of the general public took part. Sampling was carried out to make sure responses were spread across the UK, and further weighting was applied across key demographic attributes ensure the survey is nationally representative. As part of the EBM, we are also currently surveying STEM teachers on similar topics.

Knowledge of engineering and available routes

Two key messages pervade the results of the 2017 EBM. Firstly, both young people and adults tend to have a positive view of engineering – although not as positive as their view of science and technology. However, their knowledge of what the profession actually entails lags behind this positivity. Over half of young people aged 11 to 19 who took part in our survey stated they had quite or very positive views of engineering. But when asked how much they know about what people working in engineering do, 37% of those aged 11 to 16 and 43% of those aged 16 to 19 stated they knew "only a little" or "almost nothing".

EngineeringUK

Stephanie Neave,
Head of Research, EngineeringUK

Both young people and adults tend to have a positive view of engineering However, their knowledge of what the profession actually entails lags behind this positivity.

Similarly, while more than 3 in 5 young people aged 11 to 19 thought that engineers were "well paid", only 1 in 5 were able to accurately guess the broad salary range for the average graduate engineer; 3 in 5 thought the a salary band was much lower than it actually is. This is significant, as we found that pay was one of the most important factors for respondents when choosing a career – second only to it being something they were interested in.

3 in 5 young people

would consider going to teachers for career advice

Only 1 in 3

teachers expressed confidence in giving advice about a career in engineering

When asked whether they thought they could become an engineer if they wanted to, 30% of girls surveyed said no, compared with just 19% of boys.

This lack of knowledge extends to respondents' understanding of what is needed to become an engineer and the routes available into the profession. For example, just 37% of 11 to 19 year olds who took part agreed that they knew what to do next to become an engineer. And among those who stated they would choose an academic route into engineering over a vocational one, 23% did so because they believed that degree-level learning was a requirement to entering the profession.

It is apparent much more needs to be done to increase awareness and perceptions of the varied routes into engineering, in particular via an apprenticeship. Of the 11 to 14 year olds we surveyed, 58% indicated they knew 'almost nothing' or 'just a little' about what apprentices do and the different types of apprenticeships available.

As highlighted in this chapter, parents and teachers are well-positioned to influence the educational and career trajectories of their children. Two thirds of the young people we surveyed said they would consider going to parents/guardians for career advice, and 61% would go to teachers. Notably, these figures were even higher among 11 to 14 year olds, at 70% and 66% respectively. Yet results from our EBM indicate that knowledge of engineering is also limited for many parents and teachers. While 73% of parents stated they had a quite or very positive view of engineering, 35% also indicated they knew only a little or almost nothing about what engineers did. This has a clear bearing on their ability to support their children in making informed choices. Only 36% expressed confidence in giving advice to their children about a career in engineering – a similar proportion to the number of teachers who said the same in the EBM 2016 (35%).

It is evident from these results that further work is needed. We must enhance perceptions of the engineering profession among young people, parents, and teachers. We must also strengthen their knowledge of both the wide-ranging activity encompassed by the term 'engineering' and the diversity of routes into the profession. Promisingly, our EBM found that just 14% of respondents aged 11 to 14 stated that they "definitely do not want to become an engineer". This proportion grew larger among older age groups, which might be expected, given they are farther along in their education and more likely to have narrowed down their interests and abilities. Nevertheless, it never went above 34% of 16 to 19 year olds, which suggests there is real opportunity to inspire more young people to pursue a career in engineering.

Gender differences

Our EBM results also provide strong evidence of a gender bias in young people's perceptions and knowledge of STEM and engineering as a career path. For example, male pupils were statistically significantly more likely than their female counterparts to:

- have higher perceptions and enjoyment of STEM subjects at school
- intend to take physics GCSE (or equivalent)
- report knowing what people who work in STEM do
- see lots of examples of engineering in everyday life
- agree that a job in engineering would be interesting
- regard engineering as "interesting" rather than "dirty/messy" and/or "too complicated"
- think that being an engineer would fit well with who they are
- find an engineering career to be desirable
- have considered a career in engineering

There is also evidence of a gender bias in parental attitudes. Male parents, for example, were more likely to agree that a job in engineering would be interesting, that they see lots of examples of engineering in everyday life, and to see an engineer as a well-respected profession.

Perhaps most strikingly, when asked whether they thought they could become an engineer if they wanted to, 30% of girls surveyed said no, compared with just 19% of boys. These gender differences were present even among our youngest respondents, suggesting that they are formed at a relatively young age. Asked how much they would like to be an engineer when they are older, for example, 46% of girls aged 7 to 11 stated "not at all" or "not very much", which is almost twice the proportion of boys (25%). Untangling what drives these gender differences and how we can tackle them as a community is a key strategic priority for EngineeringUK.

Harnessing the talent pool

As our EBM findings – and, more broadly, this report – highlight, if we are to address the severe skills shortage in engineering, we must effectively harness the talent pool of young people. To be successful, this endeavour must be multi-pronged: working across the educational, government, and industry sectors; engaging with young people, teachers, and parents; and employing a variety of activities to engage young people of all backgrounds. While ultimately it is up to the young person to decide whether they want to pursue engineering, there is much work we can do as a community to ensure young people are well informed when making their educational and career decisions.

4 – Secondary education

23% of teachers who qualified in England between 2011 and 2015 had left the profession by 2016. Teacher shortages continue across all STEM subjects

There was a 10% decrease in entries for biology, chemistry and physics between 2012 and 2017

Key points

The UK government has restated its intention to reform technical education, with reforms targeted at key stage 4 and key stage 5. Summer 2017 saw the first award of new A levels in biology, chemistry, computer science, and physics, where assessment is mainly by examination. These specifications are very different to their predecessors, both in terms of structure and content, but also in the behaviours they have generated in schools and colleges.

In secondary education, policy-driven changes to school types and qualifications continue. GCSEs and A levels are undergoing substantial changes and technical levels ('T levels') are being developed.

GCSE and National 5s

Across the UK, entries for biology, chemistry and physics between 2012 and 2017 decreased by around 10%, for example, amid a backdrop of entries across all subjects increasing by 4.2% in the same period. Notably, entries for science, which as a subject previously had the second highest number of entries, have dropped by over 46% over the last five years. While in this time entries in additional science have increased (29.8%), they have done so at a lower rate than the decline observed in science. More encouragingly, however, maths remains the GCSE subject with the highest number of entries, with 770,034 entries in 2017.

The proportion of students achieving A*-C GCSE grades has been decreasing since 2014. This trend continued in 2017 across almost all English regions and Wales, with just tiny increases in Northern Ireland and the East Midlands. Across England, Wales and Northern Ireland, the proportion of pupils achieving a A*-C/9-4 GCSE grades in maths, for example, decreased by 1.6 percentage points in 2017.

Entries and attainment in Scottish Nationals level 5 ('National 5') chemistry, physics and computing science likewise saw declines in 2017.

A levels

At A-Level, entry numbers have increased in many STEM subjects over the last five years. This was most prominent in computing (up 117.9%), further mathematics (up 22.3%) and mathematics (up 11.1%). There were also modest increases in the number of entries in chemistry (up 6.3%) and physics (up 6.0%) in that same time period.

However, that STEM subject pass rates remain significantly below average is a concern. With the exception of further mathematics (88.2%) and mathematics (80.3%), A* to C pass rates for all STEM subjects were below the all subject average of 77.4% in 2017.

Teaching shortages

Though STEM teacher recruitment and retention has been a longstanding problem, it has become acute in recent years. Pupil numbers have grown by nearly half a million between 2011 and 2016, but the number of STEM specialist teachers has remained largely stagnant since 2015.

2017 marked the fifth consecutive year in England for which recruitment targets for trainee teachers were missed, with the shortfall particularly pronounced in STEM subjects. In the year 2017 to 2018, there was an estimated shortfall of 2,188 STEM trainee teachers against the DfE teacher supply model target. Only 33% of design and technology places were filled in England in that academic year, as were 68% of physics and 79% of maths positions.

Teacher retention has also not seen improvement. Of the 117,000 teachers who qualified in England between 2011 and 2015, 23% had left the profession during that time. Moreover, the proportion of those leaving for reasons other than retirement has grown from 68% in 2011 to 75% in 2014. In particular, retention of newly qualified science teachers is a concern, with recent research suggesting that they are 20% more likely to leave the profession within their first five years than similar newly qualified non-science teachers.

These shortfalls persist despite many attempts by governments across the UK to address these issues. It is therefore crucial that the government, engineering industry, and education sector work together on innovative approaches to incentivise talent into the STEM teaching profession, and to improve retention.

Gender issues

At GCSE level, girls had higher pass rates than boys in every STEM subject except maths in 2017.

Encouragingly, with the exception of design and technology, further mathematics, ICT and physics, 2017 saw small increases in the proportion of A level entrants who were female in every STEM subject.

However, their progression to STEM subjects once optional remains a clear issue. Only 27.1% of girls' A level entries in 2017 were in STEM subjects, compared with 45.6% of boys' entries. Girls remain considerably underrepresented in every STEM subjects except chemistry and biology. This is particularly pronounced within A level computing and Physics, where girls comprised just 9.8% and 21.5%, respectively, of entries in 2017.

4.1 – Context

Despite the wider political and economic upheavals of 2016 and 2017, the UK government twice restated its intention to reform technical education: in the budget speech[4.1] in March 2017 and in the Queen's speech at the state opening of parliament, after the 2017 general election.[4.2]

These reforms are targeted at key stage 4 and key stage 5. They are laid out in the *Post-16 Skills Plan*,[4.3] which sets out: "our ambitious framework to support young people and adults to secure a lifetime of sustained skilled employment and meet the needs of our growing and rapidly changing economy." The Post-16 Skills Plan is discussed in more detail in **Chapter 5**.

> T- levels are intended to be "a gold standard for technical and professional excellence," to be developed "through a genuine partnership between business, government and education professionals."

Technical routes are being developed in 15 sector areas, including digital, engineering and manufacturing, and health and science, as part of the "government's planned overhaul of technical education […] where substantial technical training is required to progress into employment." First teaching of a few 'pathfinder' routes should start in September 2019, with the rest of the sectors fully developed by September 2022.[4.4] These are being popularly referred to as 'T levels'. They will be "a gold standard for technical and professional excellence," to be developed "through a genuine partnership between business, government and education professionals," according to the former Secretary of State for Education, Justine Greening.[4.5]

The Institute for Apprenticeships was launched by the Department for Education (DfE) on 1 April 2017 as an employer-led body charged with ensuring high-quality apprenticeship standards and assessment plans in England. From April 2018, this remit will expand to include responsibility for technical education. The Institute for Apprenticeships also advises government on funding for each standard, and is an executive non-departmental public body, sponsored by DfE.[4.6]

University technical colleges and studio schools

The continuing evolution of the school landscape in England (**Figure 4.1**) is potentially providing scope for schools, and therefore students, to specialise in STEM subjects and get hands-on vocational experience.

University technical colleges (UTCs), through their focus on technical and practical learning, and studio schools, which often specialise in STEM, are intended to be central to this evolution. As of September 2017, there were 49 UTCs and 39 studio schools open. [4.7] Their introduction has had mixed results in terms of recruitment, incoming student profiles, absence rates, student performance, and achieving performance measures (which the National Foundation for Educational Research suggests should be modified for UTCs).[4.8]

A May 2017 report from the Institute for Public Policy Research says that, "UTCs and studio schools are failing to meet their own stated aims […and …] structural barriers to the recruitment of 14 year olds makes them highly vulnerable to falling into a 'cycle of decline'."[4.9] While the Baker Dearing Educational Trust has rebuffed these findings as "flawed and incomplete," it has acknowledged that achieving the Trust's original aims and objectives "has proved harder to achieve than we anticipated."

This may partly be because UTCs are in competition with other schools and colleges to recruit students who will get high grades to improve school performance measures. This may dissuade other schools and colleges from telling their higher performing students about UTCs. However, since spring 2017, local authorities have been obliged to write to parents of year 9 children to inform them of the existence of their local UTC. From January 2018, UTCs are also entitled to go into local schools to explain what they offer.[4.10]

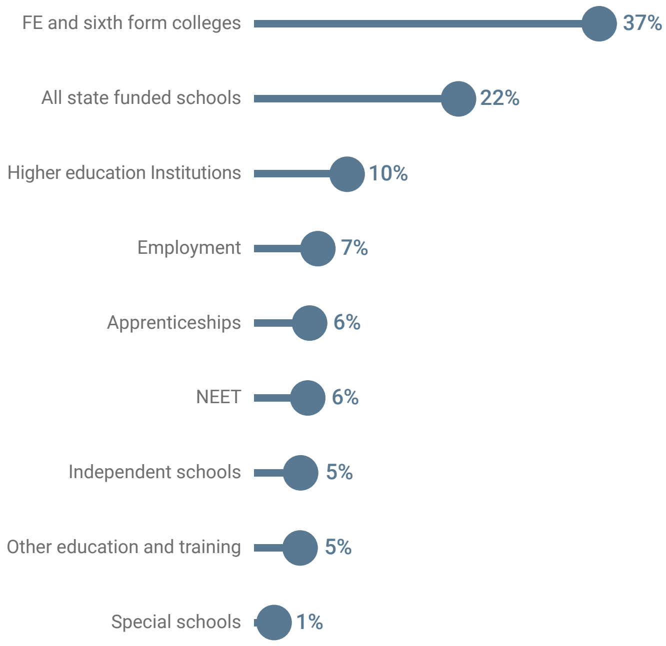
Similarly, studio schools have also had a mixed reception. Schools Week reported at the end of June 2017 that ministers met with the Studio Schools Trust to discuss a review of the studio school model, although this was denied by David Nicoll, the Studio Schools Trust's chief executive.[4.11]

Nevertheless, the DfE's figures suggest that, overall, the numbers of pupils being taught in UTCs and studio schools are increasing. Still, the proportion of pupils taught in UTCs and studio schools remains very small: 1.06% of the total cohort (15,536 out of 1,466,247) in January 2017, up from 0.93% in January 2016 (13,910 out of 1,490,813). By far the largest group of 16 to 18 year olds in England are at further education or sixth form colleges (**Figure 4.1**).[4.12]

Only 26% (up from 24% in 2016) of UTC pupils are girls, compared to 43% (no change) in studio schools.[4.13] At least 7 UTCs have closed, citing low pupil numbers, lack of financial viability, poor attendance and, in some cases, critical Ofsted reports.[4.14] Former Education Secretary, Michael Gove, said in February 2017 that, "dividing our children at 14 has not worked." [4.15]

4.1 HM Treasury. 'Spring Budget 2017: Philip Hammond's speech', March 2017.
4.2 Cabinet Office. 'Queen's Speech 2017', June 2017.
4.3 BIS and DfE. 'Post-16 Skills Plan', July 2016.
4.4 Schools Week.' What are T-levels?', March 2017.
4.5 DFE. 'Justine Greening: Speech at the Business and Education Summit', July 2017.
4.6 The Institute for Apprenticeships. 'About us.'
4.7 Studio Schools Trust. 'Current School locations'.
4.8 NFER. 'University Technical Colleges: Beneath the Headlines', June 2017.
4.9 IPPR. 'Tech Transitions', May 2017.
4.10 Baker Dearing Educational Trust. 'Baker Dearing Educational Trust responds to IPPR report', June 2017.
4.11 Schools Week. 'Minister met with key studio school officials to discuss 'review' of model', June 2017.
4.12 Association of Colleges. 'College Key Facts 2016/17', 2016.
4.13 DfE. 'Schools, pupils and their characteristics: January 2016 and 2017', June 2017.
4.14 House of Commons Library. 'University Technical Colleges', March 2016.
4.15 The Times. 'Dividing our children at 14 has not worked', February 2017.

Figure 4.1 Where 16 to 18 year olds are studying or working (2017) – England



Source: Association of Colleges, 2017

School performance measures in England

Performance in all schools in England is now measured using Attainment 8 (based on the raw results across individual pupils' best 8 GCSE subjects) and Progress 8 (based on attainment in 8 GCSEs compared against the results of pupils who came into secondary schools nationally with the same attainment levels). This process is repeated for measurement of attainment and progress post-16.[4.16, 4.17]

Although the government initially restated its target for 90% of all year 10 pupils to enter the EBacc in the Conservative Party 2017 general election manifesto,[4.18] it subsequently decreased it to 75% of year 10 pupils in state funded mainstream schools by September 2022.[4.19] Still, this target appears ambitious. In 2016, 40.3% of pupils in state-funded mainstream schools entered the EBacc, more than in previous years but still below target. Preliminary statistics for 2017 also suggest this has since dropped to 38.8%[4.20]

Further, just 21.5% of pupils in state-funded schools achieved the EBacc headline measure. To do this a pupil must achieve grade 5 or above in either GCSE English language or literature, a grade 5 or above in maths, and a grade C or above in at least 2 sciences, a language and history or geography. This is low partly due a drop in entries to EBacc languages, and to some pupils taking unreformed maths or English GCSEs that do not count in the 2017 performance tables.[4.21]

Schools in England

In England following successive layers of government reforms over the decades, there are many different types of centre that deliver school education. This panel briefly explains the general characteristics of the more common types. The landscape is complex so there may be exceptions.

Independent, private fee paying, schools, are not obliged to follow the national curriculum or employ staff qualified in teaching and can select by academic performance for admission.

State maintained schools are publicly funded via local authorities (in voluntary aided schools the governing body contributes approximately 10% of capital costs). All are required to follow the national curriculum and employ those with Qualified Teacher Status; they cannot select by academic performance. Accountability is immediately to the local authority for community and voluntary controlled schools and can be for foundation schools. Otherwise, for foundation schools and voluntary aided schools accountability is via their governing body. In community schools the premises is owned by the local authority who also employs the school staff. For voluntary aided and voluntary controlled schools, if the founding body is the church these are sometimes referred to as faith schools.

Grammar schools, while required to follow the national curriculum and employ qualified teachers, can select for admissions by academic performance. Although they are funded via the local authority accountability may be via either the local authority or governing body.

Academies, which either can be primary or secondary schools, are classified as independent although they are publicly funded via central government. They are not required to follow the national curriculum or employ staff with Qualified Teacher Status. Oversight is via an academy trust. Free schools are academies which are new (rather than converted existing schools). Academies can also be described as 'convertor' (former schools that were deemed to be performing well) or 'sponsored' (former schools often deemed to be underperforming and now run by sponsors). University technical colleges (UTCs) and studio schools are both academy types for catering to 14-18/19 year olds only. Both have a strong vocational orientation, with the latter being smaller in size. Each UTC is backed by employers and a university.

Further education (FE) colleges can also offer provision (including general education) post 14 and **sixth form colleges** post 16.

4.16 BBC News. 'All you need to know about secondary school league tables', January 2017.
4.17 TES. 'GCSE Results Day: How does Progress 8 work?', August 2017.
4.18 Schools Week. 'EBacc results 2016: Languages and art entries fall, while science soars', October 2016.
4.19 DfE. 'School Curriculum' (written ministerial statement), July 2017.
4.20 DfE. 'Provisional GCSE and equivalent results in England, 2016 to 2017' (SFR57/2017), 12 October 2017.
4.21 Ibid.

For EBacc science, a pupil must enter either three separate sciences (out of biology, chemistry, physics, computer science), core and additional science, or double science. The proportion of pupils from state-funded secondary schools entering EBacc science increased to 91.2% in 2017, by 4.5 percentage points. Most of this increase came from more pupils entering core and additional science. 65.6% of the cohort took this combination.

Concern has been expressed that these measures are reducing curriculum choices by prioritising English Baccalaureate (EBacc) subjects over others.[4.22, 4.23] This includes comments from former Conservative Education Secretary, Lord Baker: "This narrow academic curriculum will severely limit access to technical and creative subjects of the very kind needed in our new digital age." [4.24]

The requirement for those who failed maths or English GCSE to resit them has also been challenged as a policy more likely to reinforce failure than lead to success.[4.25] The condition relating to funding requires schools and colleges to re-enter candidates who achieved a grade D in maths and/or English. This was going to be removed.[4.26] However, this was reversed and the resits policy remains.[4.27]

Schooling in Wales and Northern Ireland

Schooling in Wales appears to be improving. Schools here are ranked using the Welsh government's National School Categorisation System. This takes into account quality of leadership, teaching and learning, as well as performance data, which includes whether they have achieved the minimum standard of 32% of pupils gaining five A* to C or better GCSE or vocational qualifications. Numbers of pupils having free school meals are also looked at.[4.28] In January 2017, 65% of Welsh secondary schools were in the top 2 performing categories.

In July 2017, Welsh Education Secretary Kirsty Williams also announced a £3.2 million drive to improve how maths is taught in Welsh schools. The 'network for excellence' will include advice and resources, as well as staff development opportunities.[4.29] The Welsh Assembly has also announced a £1.3 million programme to set up 300 clubs to teach computer coding to 3 to 16 year olds.[4.30]

In Northern Ireland, there were no major changes affecting the awarding of Council for the Curriculum, Examinations and Assessment (CCEA) A levels or GCSEs this summer: GCSE grades continue to be reported on the letter grade scale – that is, from A* to G.[4.31] However, the first awards for CCEA revised AS levels were made in summer 2017, as were the first A level awards for non-CCEA courses started in September 2015.[4.32] CCEA has launched a new GCSE in statistics, which was available for teaching from September 2017.[4.33] School performance tables are not published in Northern Ireland.

Case study – Banbury Aspiration Campus, Space Studio Banbury and Banbury Academy

Sylvia Thomas, Executive Principal, Banbury Aspiration Campus

Despite the challenges facing schools in the current economic climate, we believe that on the Banbury Aspirations Campus we have made some strategic decisions that have meant that we have been able to drive forward with our clear ambition to become a high quality provider of STEM education. A cornerstone of our offer is to provide our students with access to employers across a wide range of disciplines. At Space Studio Banbury (SSB), this is focused on those industries and organisations which rely on employees with high skill levels in STEM subjects. This year, we found ourselves faced with the task of reigniting some lapsed relationships and trying to find more employers who are very local to the campus because transport costs are getting prohibitive. The challenge now is to keep these authentic opportunities active, whilst also doing the day job of providing high class lessons. One of our most innovative ideas has been to invite people to have lunch with the students on a Thursday, providing a more informal opportunity for them to have career-related conversations with those at the forefront of their professions.

Our decision to work as a campus with joint staffing has proved beneficial in terms of recruitment of high quality teachers. We have been creative with our management of the curriculum to ensure that we can continue to provide a broad range of courses for those students who have chosen to study at SSB. Thus, students who would like to do a performing arts subject have been given the opportunity to do so using facilities at Banbury Academy (BA). Despite budget constraints, we have not resorted to narrowing the offer or creating much larger classes. It remains to be seen whether it is possible to continue to do this if budgets continue to be reduced in real terms.

4.22 TES. 'GCSE Results Day: How does Progress 8 work?', August 2017.
4.23 House of Commons Library. 'Briefing paper: English Baccalaureate', September 2017.
4.24 The Edge Foundation. '14-19 Education: a new Baccalaureate', 2016. p4.
4.25 The Telegraph. 'Abandon resits because they almost always end in failure, former exam board head says', August 2017.
4.26 FE Week. 'Exclusive: DfE will scrap forced resits for GCSE English and maths', March 2017.
4.27 TES. 'English and maths GCSE resits not scrapped for 2017-18', April 2017.
4.28 WalesOnline. 'This is what each of Wales' colour codes for schools means', January 2017.
4.29 BBC News. '£3m maths network to improve teaching in Welsh schools', July 2017.
4.30 BBC News. '£1.3m to expand school computer coding clubs in Wales', June 2017.
4.31 CCEA. 'QualsNI', 2016.
4.32 CCEA. 'Summer 2017 exams - CCEA Regulator writes to schools', June 2017.
4.33 CCEA. 'CCEA launches NEW GCSE Statistics qualification', June 2016.

The intention behind the nine to one grading system "is that by dividing grades up even more, it will be easier for teachers, colleges and potential employers to differentiate between average students and excellent ones."

4.2 – GCSEs and National 5s

Across the UK, the GCSE landscape is changing. Summer 2017 saw the first GCSE maths and English results issued in England using the 9 to 1 grading system.[4.34] Sciences will follow in summer 2018. As reported in the Times Educational Supplement in August 2017, "the idea was quite explicitly to kick-start a new era with new qualifications and new grading."[4.35] Cath Jadhav, Ofqual's Associate Director of Standards and Comparability, said in The Telegraph in August 2017 that the intention "is that by dividing grades up even more, it will be easier for teachers, colleges and potential employers to differentiate between average students and excellent ones."[4.36]

The Ofqual blog in April 2017 predicted that instead of 20% of entrants in maths getting an A or above, 20% would get grade 7 or above. While 7% would get an A*, 3% would get a 9, the highest grade[4.37] (In fact, 3.5% achieved a graded 9 in mathematics in 2017).[4.38] The change to the grading system is predicted to lead to a large increase in re-sits for maths and English GCSEs, as more learners fail to achieve at least a grade 4.[4.39] The proportion of pupils achieving grade C/7 in maths in 2017 was 1.6 percentage points lower than in 2016 (see **Figure 4.6**).

Scotland has also changed the way it assesses children's achievement at around age 16. In September 2016, the Scottish government announced the removal of mandatory unit assessment for National 5 (equivalent to GCSE) courses from 2017 to 2018 and Higher courses from 2018 to 2019.[4.40] A clarifying statement was released in March 2017, stating that "the removal of mandatory unit assessments has the distinct purpose of reducing the amount of assessment experienced by young people taking national qualifications and the teacher workload created as a result of administering the units. The course aims, content and rationale are not changing."[4.41]

GCSE entries

GCSE entry trends between 2012 and 2017 have been mixed but often with declining entry numbers and, particularly for technology subjects, skewed towards entries by boys. This is important as GCSE entries are a major indicator of skills at the beginning of the engineering talent pipeline.

While entries for all subjects have increased by 4.2% over the last five years, entries for many of the science subjects have declined in that period. Maths had the highest number of entries across England, Wales and Northern Ireland (**Figure 4.2** and **Figure 4.3**). At 770,034 entries, it had increased by 1.7% compared to 2016 and by 13.9% since 2012. In previous years, science had the second highest number of entries. However in

Case study – GCSE grading changes

Cath Jadhav, Associate Director - Standards and Comparability, Ofqual

GCSE grades in England are changing. Instead of letters, they'll be numbered 9 to 1, with 9 being the highest grade. The first subjects to change were English language, English literature and maths in summer 2017. In 2018, most other subjects will follow suit and, by 2020, all GCSEs will be graded 9 to 1.

The main reason for introducing the new grades is to provide greater, and more accurate, recognition of the level of each student's performance in any subject. It will also show that students have studied new, more challenging GCSE content. Fewer students will get a 9 compared to an A*. However, broadly the same proportion will get a grade 4 and above as previously got a grade C or above in the first year each new subject is awarded.

The new grades have been in development since 2013 and have been the subject of much thought over the past 5 years. During that time, we've been talking to teachers, parents, students, further and higher education and employers, to explain the new scale. We appreciate it will take time for the new grades to fully embed in everyone's thoughts but we'll keep communicating as much as we can as more new GCSEs are rolled out.

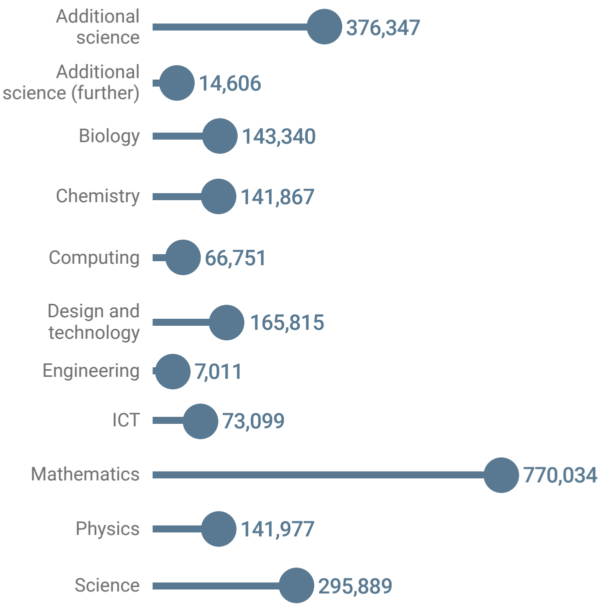
New grading structure	Current grading structure
9 8 7	A* A
6 5 4	B C
3 2 1	D E F G
U	U

4.34 Wales and Northern Ireland are retaining lettered grades A*-G for their GCSEs.
4.35 TES. 'It's impossible to compare GCSE results, so don't try', August 2017.
4.36 The Telegraph. '"We don't want chaos and confusion": Meet the woman behind the new GCSE grades', August 2017.
4.37 Ofqual blog. 'Setting grade 9 in new GCSEs', April 2017.
4.38 JCQ. 'GCSE Examination Results', July 2017.
4.39 TES. 'Crippling' GCSE English and maths resits set to rise again', July 2017.
4.40 Scottish Government. 'Action on teacher workload confirmed', September 2016.
4.41 Assessment and National Qualifications Group. 'Changes to the National Qualifications', March 2017.

2017, entries dropped to 295,889: down 27.6% on the previous year and down 46.4% since 2012. Conversely, as noted earlier in this chapter, there were more entries for additional science (376,347). Entries for separate science subjects were in the low 140,000s and have declined between 2012 and 2017 by about 10%, although entries for chemistry increased marginally and entries for physics increased by 1.6% between 2016 and 2017. GCSE computing entries continued to rise by 6.9% from 2016 to 2017, while design and technology entries fell another 10.5% between 2016 and 2017.

Most of the STEM subject entries were broadly equal between girls and boys, except in maths and biology were there clearly more female than male entries. Even here, these majorities were less than a single percentage point. There were also some notable exceptions (Figure 4.4). Only 38.9% of GCSE ICT entries and 38.9% of GCSE design and technology were by girls. Just a fifth (19.8%) of computing entries and only 9.8% of engineering entries were by girls.

Figure 4.2 Total number of GCSE full course entries for selected STEM subjects (2016 to 2017) – UK



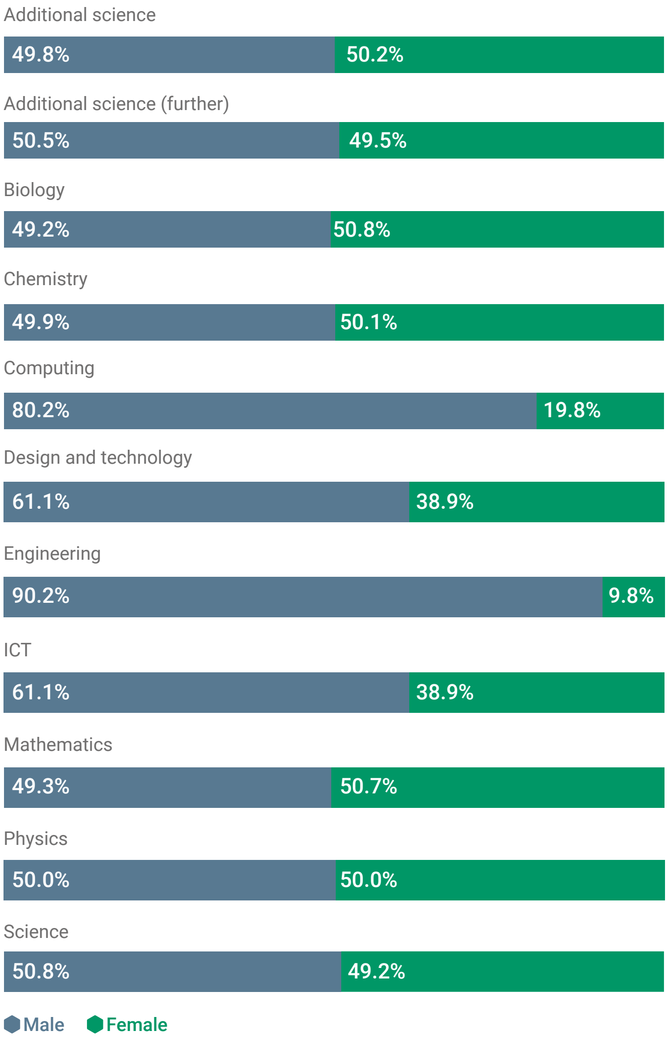
Source: JCQ, 2016/17
To view this chart with numbers by gender, see Figure 4.2 in our Excel resource.

Figure 4.3 GCSE full course entries for selected STEM subjects (2016 to 2017) – UK

Subject	No.	Change over 1 year (%)	Change over 5 years (%)
Additional science	376,347	2.3% ▲	29.8% ▲
Additional science (further)	14,606	-16.1% ▼	–
Biology	143,340	-0.6% ▼	-13.7% ▼
Chemistry	141,867	0.4% ▲	-10.8% ▼
Computing	66,751	6.9% ▲	–
Design and technology	165,815	-10.5% ▼	-31.1% ▼
Engineering	7,011	-9.1% ▼	229.5% ▲
ICT	73,099	-13.1% ▼	37.4% ▲
Mathematics	770,034	1.7% ▲	13.9% ▲
Physics	141,977	1.6% ▲	-9.8% ▼
Science	295,889	-27.6% ▼	-46.4% ▼
All subjects	**5,443,072**	**3.9% ▲**	**4.2% ▲**

Source: JCQ, 2012/2013, 2016/2017
To view this table with numbers from 2012 see Figure 4.3 in our Excel resource.
'–' denotes no value available as subject was introduced after 2012.

Figure 4.4 GCSE full course entries for selected STEM subjects by gender (2016 to 2017) – UK



Source: JCQ, 2016/2017
To view this chart with numbers, see Figure 4.4 in our Excel resource.

Figure 4.5 GCSE full course results for selected STEM subjects (2016 to 2017) – UK

Subject		Entrants	Percentage achieving A*-C/ 9-4	Number of students achieving A*-C/ 9-4
Additional science	Total	376,347	58.2%	219,034
	Male	187,422	54.5%	102,145
	Female	188,925	61.9%	116,945
	% Female	*50.2%*		*53.4%*
Additional science (further)	Total	14,606	75.2%	10,984
	Male	7,369	73.7%	5,431
	Female	7,237	76.7%	5,551
	% Female	*49.5%*		*50.5%*
Biology	Total	143,340	90.4%	129,579
	Male	70,497	89.3%	62,954
	Female	72,843	91.4%	66,579
	% Female	*50.8%*		*51.4%*
Chemistry	Total	141,867	89.9%	127,538
	Male	70,723	88.3%	62,448
	Female	71,144	91.4%	65,026
	% Female	*50.1%*		*51.0%*
Computing	Total	66,751	60.8%	40,585
	Male	53,519	59.6%	31,897
	Female	13,232	65.7%	8,693
	% Female	*19.8%*		*21.4%*
Design and technology	Total	165,815	61.2%	101,479
	Male	101,271	53.8%	54,484
	Female	64,544	72.9%	47,053
	% Female	38.9%		46.4%
Engineering	Total	7,011	44.0%	3,085
	Male	6,325	41.7%	2,638
	Female	686	65.7%	451
	% Female	*9.8%*		*14.6%*
ICT	Total	73,099	66.9%	48,903
	Male	44,634	64.0%	28,566
	Female	28,465	71.6%	20,381
	% Female	*38.9%*		*41.7%*
Mathematics	Total	770,034	59.4%	457,400
	Male	379,724	59.9%	227,455
	Female	390,310	58.9%	229,893
	% Female	*50.7%*		*50.3%*
Physics	Total	141,977	90.8%	128,915
	Male	71,003	90.5%	64,258
	Female	70,974	91.1%	64,657
	% Female	*50.0%*		*50.2%*
Science	Total	295,889	48.0%	142,027
	Male	150,332	45.0%	67,649
	Female	145,557	51.2%	74,525
	% Female	*49.2%*		*52.5%*
All subjects	**Total**	**5,443,072**	**66.3%**	**3,608,757**
	Male	**2,700,343**	**61.5%**	**1,660,711**
	Female	**2,742,729**	**71.0%**	**1,947,338**
	% Female	***50.4%***		***54.0%***

Source: JCQ, 2016/2017
To view this table with numbers from 2015, see Figure 4.5 in our Excel resource.

GCSE and National 5 results

In terms of actual results, provisional figures show there was a slight decrease in achievement in maths in England, Wales and Northern Ireland in 2017. The number of pupils achieving grades A*-C/9-4 decreased by 1.6 percentage points (Figure 4.6). The proportion of girls in the cohort remained stable, at 50.7% in 2017 against 51.0% in 2016 (Figure 4.5 and Excel resource). However, the proportion of girls who achieved top grades went down very slightly: 50.3% achieved A*-C/9-4 in 2017, compared with 50.9% in 2016. These are small percentage differences, but equate to 2,923 girls. Still, in 2017 female pupils had higher pass rates than males for every STEM subject except maths.

The GCSE A* to C pass rate for ICT in 2017 was 66.9% (Figure 4.6), very close to the all-subject pass rate (66.3%). The pass rates for biology, chemistry, physics, further additional science and statistics were all higher. The pass rates for science, additional science, computing, design and technology, engineering and maths were lower. The stark contrast in pass rates between science and the individual disciplines of biology, chemistry and physics can be attributed to the effects of streaming by attainment. Only the top learners are entered for the separate science subjects. The same is generally true of further additional science, which when taken with science and additional science also leads to 3 science GCSEs.

Figure 4.6 GCSE full course A* to C/9 to 4 pass rates for selected STEM subjects (2016 to 2017) – UK

Subject	Percentage	Change over 1 year (%p)	Change over 5 years (%p)
Additional science	58.2%	-1.5%p ▼	-8.2%p ▼
Additional science (further)	75.2%	-1.7%p ▼	–
Biology	90.4%	-0.1%p ▼	-2.2%p ▼
Chemistry	89.9%	-0.4%p ▼	-3.1%p ▼
Computing	60.8%	0.4%p ▲	–
Design and technology	61.2%	0.3%p ▲	-1.5%p ▼
Engineering	44.0%	3.3%p ▲	-2.8%p ▼
ICT	66.9%	-1.0%p ▼	-7.8%p ▼
Mathematics	59.4%	-1.6%p ▼	1.0%p ▲
Physics	90.8%	-0.1%p ▼	-2.4%p ▼
Science	48.0%	-4.9%p ▼	-12.7%p ▼
All subjects	**66.3%**	**-0.6%p ▼**	**-3.1%p ▼**

Source: JCQ, 2012/2013, 2016/2017
To view this table with numbers from 2012, see Figure 4.6 in our Excel resource.
'–' denotes no value available as subject was introduced after 2012.

Figure 4.7 Proportion of GCSE full course entries achieving A* to C/9 to 4 grades by nation/region (2016 to 2017)

Region	Percentage	Change over 1 year (%p)	Change over 3 years (%p)
England	66.1%	0.4%p ▲	-1.8%p ▼
North East	63.4%	-1.6%p ▼	-2.3%p ▼
North West	64.4%	-1.1%p ▼	-3.9%p ▼
Yorkshire and the Humber	63.2%	-0.3%p ▼	-1.7%p ▼
East Midlands	64.1%	0.5%p ▲	-1.6%p ▼
West Midlands	63.6%	-0.4%p ▼	-3.1%p ▼
Eastern	66.5%	0.0%p	-2.3%p ▼
London	69.9%	-0.2%p ▼	-1.8%p ▼
South East	68.7%	-0.7%p ▼	-2.2%p ▼
South West	66.6%	-0.3%p ▼	-2.4%p ▼
Wales	62.8%	-3.8%p ▼	-3.8%p ▼
Northern Ireland	79.5%	0.4%p ▲	1.5%p ▲
UK	**66.3%**	**-0.6%p ▼**	**-2.5%p ▼**

Source: JCQ, 2014/2015/2016/2017
To view this table with numbers from 2014, see Figure 4.7 in our Excel resource.

Pass rates by region

Looking at pass rates by region shows that the proportion of GCSE entries achieving an A*-C grade decreased in 2017 across almost all English regions and Wales, with tiny increases in Northern Ireland and the East Midlands. This continues the trend from 2014, albeit at a slower rate (Figure 4.7).

The situation is similar in Scotland, where entries and attainment in Scottish Nationals level 5 ('National 5') biology, chemistry, physics and computing science continued to decline (apart from a very small increase in biology entrants). However, minority entry subjects such as design and manufacture, practical electronics, metalworking and woodworking showed modest increases in both entries and attainment (Figure 4.8).[4.42]

Across almost all English regions and in Wales, the proportion of GCSE entries achieving an A*-C grade decreased in 2017.

The situation is similar in Scotland, where entries and attainment in Scottish Nationals level 5 ('National 5') biology, chemistry, physics and computing science continued to decline.

4.42 JCQ. 'GCSE Examination Results', 2017.

Figure 4.8 Attainment in selected STEM National 5 qualifications (2016 to 2017) – Scotland

Subject		2016/2017	Change over 1 year
Administration and IT	Entrants	5,477	0.5% ▲
	Percentage A-C	79.2%	0.4%p ▲
	Number A-C	4,336	1.0% ▲
Biology	Entrants	21,417	1.0% ▲
	Percentage A-C	71.3%	-2.0%p ▼
	Number A-C	15,277	-1.7% ▼
Chemistry	Entrants	16,399	-3.8% ▼
	Percentage A-C	76.4%	0.3%p ▲
	Number A-C	12,529	-3.4% ▼
Computing science	Entrants	7,442	-6.1% ▼
	Percentage A-C	82.1%	-0.3%p ▼
	Number A-C	6,108	-6.5% ▼
Design and manufacture	Entrants	4,980	1.6% ▲
	Percentage A-C	83.8%	0.2%p ▲
	Number A-C	4,174	1.8% ▲
Engineering science	Entrants	1,744	-4.8% ▼
	Percentage A-C	79.4%	-1.4%p ▼
	Number A-C	1,384	-6.5% ▼
Fashion and textile technology	Entrants	549	-3.9% ▼
	Percentage A-C	92.5%	0.2%p ▲
	Number A-C	508	-3.6% ▼
Health and food technology	Entrants	1,786	-6.2% ▼
	Percentage A-C	71.8%	-10.7%p ▼
	Number A-C	1,282	-18.3% ▼
Lifeskills mathematics	Entrants	2,599	-7.0% ▼
	Percentage A-C	46.5%	10.7%p ▲
	Number A-C	1,208	20.8% ▲
Mathematics	Entrants	42,191	1.0% ▲
	Percentage A-C	63.8%	0.6%p ▲
	Number A-C	26,927	1.9% ▲
Music technology	Entrants	852	14.4% ▲
	Percentage A-C	87.9%	-0.8%p ▼
	Number A-C	749	13.3% ▲
Physics	Entrants	14,165	-4.9% ▼
	Percentage A-C	73.1%	-0.9%p ▼
	Number A-C	10,359	-6.0% ▼
Practical electronics	Entrants	210	76.5% ▲
	Percentage A-C	77.6%	1.1%p ▲
	Number A-C	163	79.1% ▲
Practical metalworking	Entrants	1,243	8.2% ▲
	Percentage A-C	92.0%	-2.9%p ▼
	Number A-C	1,144	5.0% ▲
Practical woodworking	Entrants	4,560	4.4% ▲
	Percentage A-C	92.6%	-1.7%p ▼
	Number A-C	4,222	2.6% ▲
All subjects	**Entrants**	**293,220**	**-0.6%** ▼
	Percentage A-C	**79.5%**	**0.1%p** ▲
	Number A-C	**233,005**	**-0.5%** ▼

Source: SQA, 2014/2015, 2016/2017
To view this table with numbers from 2015, see **Figure 4.8** in our Excel resource.

4.3 – A levels, Highers and Advanced Highers

Professor Sir Adrian Smith's review into the feasibility of compulsory mathematics for all pupils up to 18 was published by the Department for Education in July 2017.[4.43] It makes the case for strengthening the post-16 core mathematics offer, ensuring that all schools and colleges are equipped and staffed to offer it, and that funding and performance measures encourage, rather than discourage, the offer. The report also calls for the need to better understand how the mathematics teaching workforce is trained and developed, and for universities to be encouraged to support post-16 mathematics teaching, especially in areas where level 3 mathematics participation and achievement are poor.

The Minister of State for School Standards, Nick Gibb MP, responded to the report by announcing a £16 million level 3 maths support programme to "work with schools and colleges to improve mathematics education by sharing best practice, and delivering knowledge-rich curriculum materials, as well as working to increase participation and attainment in 16 to 18 mathematics." He also stated that the programme will work to deliver focused intervention targeted to those who need it most. His response refers to existing government initiatives, such as those referenced in the government green paper, *Building our industrial strategy*,[4.44] and to the development of a careers strategy later in 2017.[4.45]

Summer 2017 saw the first award of new 'linear' A levels in biology, chemistry, computer science, and physics, where assessment is mainly by examination at the end of the course. Other types of assessment are used only where they are needed to test essential skills. These specifications are very different to their predecessors, both in terms of structure and content, but also in the behaviours they have generated in schools and colleges. Ofqual have found schools' and colleges' responses to taking AS levels have varied. Some have been entering students for AS in all their A level subjects. Others have been using AS only if the pupil drops that subject, or have made no changes at all.[4.46] Specifications for linear A levels in mathematics, further maths, design and technology, and statistics have been developed and accredited for first teaching from September 2017.[4.47, 4.48]

A level entries

Overall, entries across all A level subjects decreased by 1% between 2016 and 2017, and by 3.9% over the last five years (**Figure 4.9**). There were more entries by girls (454,701) than boys (373,654) for all subjects. Female entrant numbers fell by 0.3% in the last year, but have gone up by 0.8% over five years.

With 92,163 entries, mathematics was the most popular subject by entries, as was also the case in 2016 (**Figure 4.10** and **Figure 4.11**). Biology ranked second with 61,908 entries and chemistry fourth with 52,331 entries. Physics was ninth with 36, 578 entries. Both physics and chemistry had more entries than in 2016. Entry numbers for A level technology subjects were lower than the science subjects. Entries for ICT, computing and design and technology combined were 28,321.

Figure 4.9 GCE A level STEM subject entrant numbers (2016 to 2017) – all UK candidates

Subject		Entrants	Change over 1 year	Change over 5 years
Biology	Entrants	61,908	-1.2% ▼	-1.8% ▼
	% Female	*61.7%*	*0.6%p* ▲	*5.2%p* ▲
Chemistry	Total Entrants	52,331	1.0% ▲	6.3% ▲
	% Female	*50.9%*	*0.9%p* ▲	*3.6%p* ▲
Computing	Total Entrants	8,299	33.0% ▲	117.9% ▲
	% Female	*9.8%*	*0.1p%* ▲	*2.0%p* ▲
Design and technology	Total Entrants	12,415	-0.5% ▼	-27.4% ▼
	% Female	*38.1%*	*-0.5%p* ▼	*-4.5%p* ▼
Further Mathematics	Total Entrants	16,172	6.0% ▲	22.3% ▲
	% Female	*27.5%*	*-0.1%p* ▼	*-2.6%p* ▼
ICT	Total Entrants	7,607	-12.9% ▼	-31.4% ▼
	% Female	*32.7%*	*-3.1%p* ▼	*-6.0%p* ▼
Mathematics	Total Entrants	95,244	3.3% ▲	11.1% ▲
	% Female	*39.1%*	*0.4%p* ▲	*-0.9%* ▼
Other science subjects	Total Entrants	2,840	-14.0% ▼	-15.9% ▼
	% Female	*25.4%*	*0.6%p* ▲	*2.8%p* ▲
Physics	Total Entrants	36,578	3.5% ▲	6.0% ▲
	% Female	*21.5%*	*-0.2%p* ▼	*0.1%p* ▲
All subjects	**Total Entrants**	**828,355**	**-1.0%** ▼	**-3.9%** ▼
	% Female	***54.9%***	***-0.3%p*** ▼	***0.8%p*** ▲

Source: JCQ, 2012/2013, 2016/2017
To view this table with numbers from 2012, see **Figure 4.9** in our Excel resource.

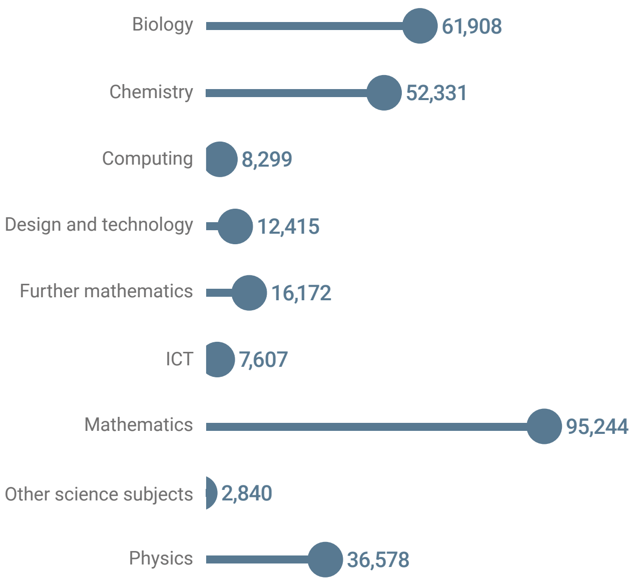
4.43 Smith. 'Report of Professor Sir Adrian Smith's review of post-16 mathematics', July 2017.
4.44 HM government. 'Building our industrial strategy: Green paper', January 2017.
4.45 DfE. 'Independent review of 16-18 maths education' (letter), July 2017.
4.46 Ofqual blog. 'Comparable outcomes and new A levels', March 2017.
4.47 Ofqual. 'Summary of changes to AS and A levels from 2015', March 2017.
4.48 Ofqual. 'GCSE, AS and A level subjects accredited to be taught from 2017', September 2017.

Figure 4.10 Top 10 GCE A level subjects by entries (2016 to 2017) – all UK candidates

Ranking	Subject	Percentage of total	Number of candidates
1	Mathematics	11.5%	95,244
2	Biology	7.5%	61,908
3	Psychology	7.1%	58,663
4	Chemistry	6.3%	52,331
5	History	6.1%	50,311
6	English literature	5.6%	46,411
7	Art and design	5.3%	43,653
8	Geography	4.6%	37,814
9	Physics	4.4%	36,578
10	Sociology	4.2%	34,607

Source: JCQ, 2016/2017
To view this table with numbers from 2016, see Figure 4.10 in our Excel resource.

Figure 4.11 Total number of GCE A level STEM subject entrant numbers (2016 to 2017) - all UK candidates



Source: JCQ, 2016/2017

STEM A level entries by gender

Despite the number of A level entries among girls being generally on an upward trend, and girls making up the majority of A level entries, they are still underrepresented in STEM. In the last year, girls were outnumbered by boys in all the STEM subjects except biology and chemistry (Figure 4.9). In computing, total entries increased by 117.9% over five years, but the proportion of girls only increased by 2 percentage points, and still comprises less than 10% of overall entries. In further maths, overall entries went up by 22.3% but girls' entries fell by 0.9 percentage points. As reported in The Conversation, "girls remain considerably underrepresented in most STEM subjects – except chemistry and biology (…) The uptake of mathematics by girls has stagnated at just under 40% for years."[4.49]

STEM A level attainment

Against the trend of decreasing entries for all subjects, it is encouraging to see entry numbers increase for maths, chemistry and physics. However, there are some concerning trends in STEM when it comes to achievements. The all subject A* to C pass rate in 2017 was 77.4% (Figure 4.12). The A* to C pass rates for all STEM subjects were below the all subject average, except for further mathematics and mathematics, at 88.2% and 80.3% respectively.

The A* to C pass rates for maths and further maths each increased marginally by 0.1 percentage points between 2016 and 2017. The rate for design and technology subjects increased by 0.9 percentage points. This is encouraging, although it remains 9 percentage points below the all subject rate. In turn, the all subject rate declined marginally, by 0.2 percentage points. The rates declined in all other STEM subjects. Computing, ICT and other science subjects by less than 1 percentage point. However, the science subjects dropped by between 1.4 and 1.8 percentage points.

Over five years, with some fluctuations, the all subject A* to C pass rate increased by 0.8 percentage points. In contrast, the rates for all the STEM subjects have changed more dramatically. All have declined by at least 1 percentage point, except computing which rose by 0.4 percentage points. Physics pass rates dropped by 4.3 percentage points, ICT by 4.2 percentage points and other science subjects by 6.4 percentage points.

Set against increasing entrant numbers in A Level chemistry and physics, these falling pass rates suggest, on the face of it, that the academic performance of those taking these subjects may be lower than cohorts who entered previously. However, this does not explain the pattern in biology which shows falling entry numbers and pass rates. There may be other explanations, including to the assessment and grading changes with the introduction of linear A levels.

Figure 4.12 Proportion achieving grade A*-C at GCE A level (2016 to 2017) – all UK candidates

Subject	Percentage	Change over 1 year (%p)	Change over 5 years (%p)
Biology	70.8%	-1.8%p ▼	-2.9%p ▼
Chemistry	75.6%	-1.4%p ▼	-3.5%p ▼
Computing	61.2%	-0.9%p ▼	0.4%p ▲
Design and technology	68.4%	0.9%p ▲	-1.5%p ▼
Further mathematics	88.2%	0.1%p ▲	-1.2%p ▼
ICT	58.6%	-0.1%p ▼	-4.2%p ▼
Mathematics	80.3%	0.1%p ▲	-1.3%p ▼
Physics	69.7%	-1.7%p ▼	-4.3%p ▼
All subjects	**77.4%**	**-0.2%p ▼**	**0.8%p ▲**

Source: JCQ, 2012/2013, 2016/2017.
To view this table with numbers from 2012, see Figure 4.12 in our Excel resource.

4.49 The Conversation. 'It's a myth that boys have beaten girls in A-level results', August 2017.

Figure 4.13 Number of GCE A level passes at grades A*-C and A*-A by gender (2016 to 2017) – all UK candidates

Subject		Total number of students	Percentage A*-C	Number of students obtaining a grade A*-C	Percentage A*-A	Number of students obtaining a grade A*-A
Biology	Total	61,908	70.8%	43,831	26.2%	16,220
	Male	23,703	70.5%	16,711	25.9%	6,139
	Female	38,205	71.0%	27,126	26.4%	10,086
Chemistry	Total	52,331	75.6%	39,562	31.7%	16,589
	Male	26,615	75.7%	20,148	33.5%	8,916
	Female	25,716	75.5%	19,416	30.0%	7,715
Computing	Total	8,299	61.2%	5,079	16.9%	1,403
	Male	7,483	61.2%	4,580	17.2%	1,287
	Female	816	61.2%	499	14.7%	120
Design and technology	Total	12,415	68.4%	8,492	17.1%	2,123
	Male	7,682	64.9%	4,986	14.9%	1,145
	Female	4,733	74.1%	3,507	20.8%	984
Further mathematics	Total	16,172	88.2%	14,264	58.1%	9,396
	Male	11,731	88.2%	10,347	57.9%	6,792
	Female	4,441	88.1%	3,913	58.6%	2,602
ICT	Total	7,607	58.6%	4,458	10.0%	761
	Male	5,121	54.9%	2,811	7.9%	405
	Female	2,486	66.3%	1,648	14.2%	353
Mathematics	Total	95,244	80.3%	76,481	42.3%	40,288
	Male	58,032	79.7%	46,252	43.0%	24,954
	Female	37,212	81.3%	30,253	41.1%	15,294
Physics	Total	36,578	69.7%	25,495	29.2%	10,681
	Male	28,732	69.5%	19,969	28.8%	8,275
	Female	7,846	70.6%	5,539	30.6%	2,401
All subjects	**Total**	**828,355**	**77.4%**	**641,147**	**26.3%**	**217,857**
	Male	**373,654**	**75.3%**	**281,361**	**26.6%**	**99,392**
	Female	**454,701**	**79.2%**	**360,123**	**26.1%**	**118,677**

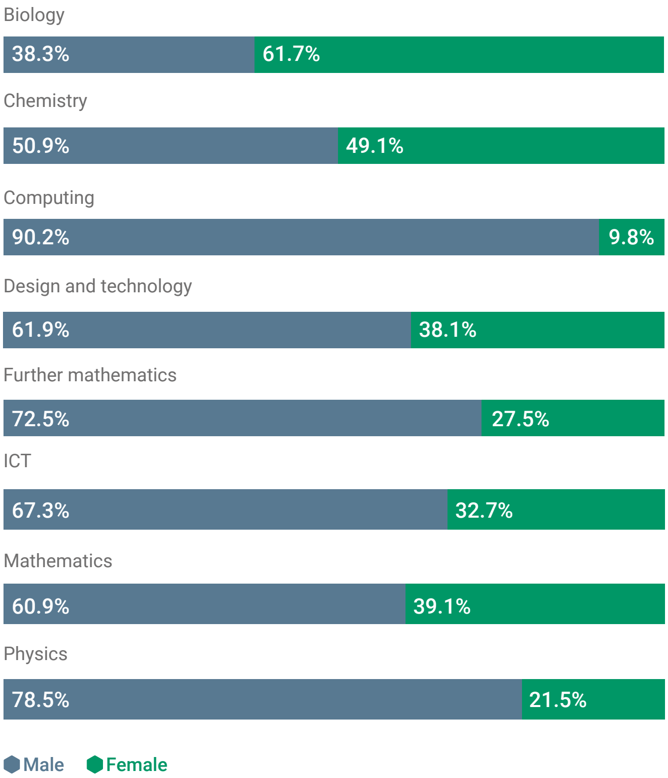
Source: JCQ, 2016/2017
To view this table with numbers from 2012, see Figure 4.13 in our Excel resource.

At the very top grades (A* to A), the picture is more encouraging. Just over a quarter (26.3%) of entrants to all subjects in the UK achieved a pass at grades A* to A grades in the academic year 2016 to 2017 (Figure 4.13). In STEM subjects, 58.1% of further mathematics students achieved the top grade, as did 31.7% of chemistry students and 29.2% of physics students. Only ICT fell below the all subject average, with just 10% of students achieving an A*-A grade.

STEM A level attainment by gender

The low proportion of STEM A level entries by girls is all the more troubling because they consistently outperform boys when it comes to attainment – even in STEM subjects (Figure 4.13 and Figure 4.14). The A* to C pass rate for all subjects in 2017 was 77.4%: 79.2% of girls achieved these grades, against 75.3% of boys. Within the STEM A level subjects, girls had higher A* to C pass rates than boys in biology, ICT, mathematics, physics, design and technology and technology subjects. In the remaining STEM subjects, the pass rate differences by gender were within 0.2 percentage points.

Figure 4.14 Percentage of GCE A level passes at grades A*-C for selected STEM subjects by gender (2016 to 2017) – all UK candidates



Source: JCQ, 2016/2017

A level attainment by UK country

In England, Wales and Northern Ireland, the proportions of A level students achieving A* to C passes in STEM subjects have changed by differing amounts. This may in part be due to the different combinations of changes in entries and pass rates. In England the number of A* to C grades have fallen by 0.9% (5,203), while in Wales there were 1,156 fewer A* to C grades (a drop of 4.4%) and in Northern Ireland there were 678 fewer A* to C grades (a drop of 2.6%) (Figure 4.15 and Excel resource).

The number of students gaining A* to C Biology grades dropped by between 3.2% in England and 6.1% in Northern Ireland. In Wales and Northern Ireland, this was caused by lower entry numbers, despite higher pass rates in 2017 compared to 2016. Northern Ireland also had higher pass rates amongst fewer entries for chemistry and physics. This caused a minimal reduction in the number of A* to C grades in chemistry but a larger reduction of 8.3% in physics. In Wales, chemistry A* to C grades also dropped, but physics grades increased by 9.8% with slightly more entries and an increase in the pass rate of 3.8 percentage points. In England, the increase in entry numbers compensated the drop in pass rates, leading to a marginal increase of 1.1% in the number of A* to C grades.

The combination of entries and pass rates increased in England, Wales and Northern Ireland led respectively to 30.3%, 27.1% and 38.6% more A* to C grades in computing. ICT in contrast had fewer A* to C grades in all 3 countries. Differences in design and technology/technology A* to C grades in each country between 2016 and 2017 were minimal.

Maths A* to C grades in Northern Ireland dropped by 6.3% and the number of further maths remained very small. Maths and further maths grades increased in England by 3.8% (2,534) and 5.8% (735). In Wales, there were 6.0% (178) more maths and 15.3% (69) further maths grades.[4.50]

Scottish Higher and Advanced Higher entries and attainment

In Scotland, of STEM subjects at Higher level, maths had the most entries (18,861), followed by chemistry (10,134) and physics (8,955) in the academic year 2017 (Figure 4.16). These entry numbers are similar to the previous academic year (see our Excel resource).

The A to C grade all subject pass rate for Highers decreased marginally by 0.2 percentage points to 77.0% between the academic years 2016 and 2017. Pass rates in the STEM subjects also generally declined. The biggest drops were in computing science (6.0 percentage points) and health and food technology (9.1 percentage points). There were, however, a few exceptions. Biology, for example, increased by 3.4 percentage points and design and manufacture and physics both increased by 1.7 percentage points.

The combination of entry numbers and pass rates meant that 13,863 A to C grades were attained in maths in the academic year 2017. In chemistry 7,675 A to C grades were attained, as were 5,466 in biology, 6,794 in physics and 2,887 in computing science.

The number of Scottish Advanced Higher entries were much lower than at Highers level. Overall, there were 24,112 entries at the Advanced Highers level in the academic year 2017, slightly higher than in 2016 (Figure 4.17). Of the STEM subjects, the highest number of entries in 2017 were in mathematics (3,586). Of these, 2,672 attained grade A to C passes, with a pass rate of 74.5%.

4.50 JCQ. 'Examination Results; A levels', 2017.

Figure 4.15 Number of GCE A level passes at grades A*-C, by gender (2016 to 2017) – England, Wales, Northern Ireland

England		Total number of entries	Percentage A*-C	Number of students obtaining a grade A*-C	Change over 1 year (n)	Change over 1 year (%)
Biology	Total	56,233	70.3%	39,532	-1302 ▼	-3.2% ▼
	Male	21,546	70.1%	15,104	-667 ▼	-4.2% ▼
	Female	34,687	70.4%	24,420	-661 ▼	-2.6% ▼
Chemistry	Total	48,212	75.1%	36,207	-203 ▼	-0.6% ▼
	Male	23,722	75.5%	17,910	-23 ▼	-0.1% ▼
	Female	24,490	74.7%	18,294	623 ▲	3.5% ▲
Computing	Total	7,592	60.4%	4,586	1,066 ▲	30.3% ▲
	Male	6,876	60.5%	4,160	1,006 ▲	31.9% ▲
	Female	716	59.5%	426	59 ▲	16.0% ▲
Design and technology	Total	10,657	68.0%	7,247	71 ▲	1.0% ▲
	Male	6,472	64.3%	4,161	58 ▲	1.4% ▲
	Female	4,185	73.8%	3,089	22 ▲	0.7% ▲
Further mathematics	Total	15,303	88.0%	13,467	735 ▲	5.8% ▲
	Male	11,112	88.0%	9,779	557 ▲	6.0% ▲
	Female	4,191	88.0%	3,688	182 ▲	5.2% ▲
ICT	Total	5,433	56.7%	3,081	-493 ▼	-13.8% ▼
	Male	3,728	53.2%	1,983	-181 ▼	-8.4% ▼
	Female	1,705	64.4%	1,098	-312 ▼	-22.1% ▼
Mathematics	Total	87,679	80.0%	70,143	2,543 ▲	3.8% ▲
	Male	53,631	79.5%	42,637	1,111 ▲	2.7% ▲
	Female	34,048	80.9%	27,545	1,412 ▲	5.4% ▲
Physics	Total	33,500	69.2%	23,182	243 ▲	1.1% ▲
	Male	26,398	69.0%	18,215	390 ▲	2.2% ▲
	Female	7,102	69.9%	4,964	-126 ▼	-2.5% ▼
All subjects	**Total**	**759,233**	**77.3%**	**586,887**	**-5,203** ▼	**-0.9%** ▼
	Male	**342,859**	**75.1%**	**257,487**	**155** ▲	**0.1%** ▲
	Female	**416,374**	**79.0%**	**328,935**	**-6,083** ▼	**-1.8%** ▼

4.4 – Diversity and social mobility initiatives

In improving progression of lower socioeconomic classes through education, the Social Mobility Commission has recently argued "progress has been too slow and results have been too piecemeal" over the last 20 years.[4.51] This sentiment has similarly been echoed in a report from London South Bank University (LSBU) and PA Consulting Group, published in July 2017.[4.52] Notably, explicit links between addressing social mobility in education and the engineering shortfall have been made. Writing about the report in The Guardian, the author, Professor David Phoenix OBE, Vice-Chancellor of LSBU, says that, "The UK's engineering industry alone will need another 1.8 million trained individuals by 2025. But we will only be able to plug these gaps if we focus on all learners, and not just those on academic courses." [4.53]

A number of initiatives are therefore working to improve social mobility into STEM and related sectors. For example, The Sutton Trust supports social mobility in STEM and in the digital sector, working with pupils in years 12 and 13 at 3 universities, and with younger students (years 7 to 10) at 5 universities.[4.54]

Other initiatives have looked to improve diversity in STEM. For example, in its Annual London Education Report in February 2017, the Greater London Authority noted that "relatively few young people in London are leaving school with A levels in this area, particularly young women and those from BAME backgrounds." As a result, the Mayor of London has introduced the Digital Talent Programme (2017 to 2019) to "focus on engaging and inspiring young women and young black and minority ethnic Londoners to train in digital, technology and creative occupations." [4.55]

4.51 Social Mobility Commission. 'Time For Change: An Assessment of Government Policies on Social Mobility 1997-2017', June 2017.
4.52 LSBU and PA Consulting Group. 'Families of Learning: Co-Creating Local Solutions to Education System Failings', July 2017.
4.53 The Guardian. 'Let's bridge the divide between academic and technical education', July 2017.
4.54 Sutton Trust. 'Programmes'. 2017.
4.55 Greater London Authority. 'Annual London Education Report 2017', February 2017.

Figure 4.15 Continued

Wales		Total number of entries	Percentage A*-C	Number of students obtaining a grade A*-C	Change over 1 year (n)	Change over 1 year (%)
Biology	Total	2,427	70.4%	1,709	-156 ▼	-8.4% ▼
	Male	957	69.7%	667	-72 ▼	-9.8% ▼
	Female	1,470	70.8%	1,041	-85 ▼	-7.6% ▼
Chemistry	Total	2,170	75.5%	1,638	-78 ▼	-4.6% ▼
	Male	1,123	74.0%	831	-53 ▼	-6.0% ▼
	Female	1,047	77.1%	807	-26 ▼	-3.1% ▼
Computing	Total	339	56.6%	192	41 ▲	27.1% ▲
	Male	307	57.3%	176	43 ▲	32.2% ▲
	Female	32	50.0%	16	-2 ▼	-11.1% ▼
Design and technology	Total	640	63.6%	407	-3 ▼	-0.7% ▼
	Male	404	57.9%	234	14 ▲	6.2% ▲
	Female	236	73.3%	173	-17 ▼	-9.0% ▼
Further mathematics	Total	588	88.8%	522	69 ▲	15.3% ▲
	Male	420	89.3%	375	74 ▲	24.7% ▲
	Female	168	87.5%	147	-5 ▼	-3.3% ▼
ICT	Total	674	37.1%	250	-133 ▼	-34.7% ▼
	Male	456	34.4%	157	-53 ▼	-25.4% ▼
	Female	218	42.7%	93	-80 ▼	-46.1% ▼
Mathematics	Total	3,931	80.4%	3,161	178 ▲	6.0% ▲
	Male	2,331	79.9%	1,862	107 ▲	6.1% ▲
	Female	1,600	81.3%	1,301	71 ▲	5.8% ▲
Physics	Total	1,568	71.4%	1,120	100 ▲	9.8% ▲
	Male	1,229	71.6%	880	83 ▲	10.5% ▲
	Female	339	70.8%	240	17 ▲	7.6% ▲
All subjects	**Total**	**33,294**	**75.3%**	**25,070**	**-1156** ▼	**-4.4%** ▼
	Male	**14,677**	**72.3%**	**10,611**	**-276** ▼	**-2.5%** ▼
	Female	**18,617**	**77.7%**	**14,465**	**-876** ▼	**-5.7%** ▼

Figure 4.16 Attainment in selected STEM Higher qualifications (2016 to 2017) – Scotland

Subject	Total entries	Percentage A to C grade	Number A to C grade	Percentage A grade	Number A grade
Administration and IT	4,099	75.4%	3,089	30.8%	1,263
Biology	7,574	72.2%	5,466	27.0%	2,045
Chemistry	10,134	75.7%	7,675	30.3%	3,067
Computing science	4,476	64.5%	2,887	19.1%	854
Design and manufacture	3,021	64.0%	1,934	14.1%	425
Engineering science	1,126	71.3%	803	17.8%	200
Fashion and textile technology	282	82.6%	233	39.4%	111
Mathematics	18,861	73.5%	13,863	31.4%	5,919
Physics	8,955	75.9%	6,794	28.1%	2,520
All subjects	**194,813**	**77.0%**	**150,010**	**28.7%**	**55,939**

Source: SQA, 2016/17
To view this table with numbers from 2015, see Figure 4.16 in our Excel resource.

Figure 4.15 Continued

Northern Ireland		Total number of entries	Percentage A*-C	Number of students obtaining a grade A*-C	Change over 1 year (n)	Change over 1 year (%)
Biology	Total	2,889	81.9%	2,366	-154 ▼	-6.1% ▼
	Male	1,046	80.3%	840	-47 ▼	-5.3% ▼
	Female	1,843	82.7%	1,524	-110 ▼	-6.7% ▼
Chemistry	Total	1,743	89.2%	1,555	-11 ▼	-0.7% ▼
	Male	753	86.2%	649	-70 ▼	-9.7% ▼
	Female	990	91.5%	906	59 ▲	7.0% ▲
Computing	Total	315	84.1%	265	74 ▲	38.6% ▲
	Male	253	83.8%	212	52 ▲	32.5% ▲
	Female	62	85.5%	53	22 ▲	71.0% ▲
Design and technology	Total	1,017	76.0%	773	-1 ▼	-0.1% ▼
	Male	725	74.6%	541	-6 ▼	-1.1% ▼
	Female	292	79.5%	232	5 ▲	2.2% ▲
Further mathematics	Total	199	95.5%	190	7 ▲	3.9% ▲
	Male	139	95.7%	133	-2 ▼	-1.4% ▼
	Female	60	95.0%	57	9 ▲	18.7% ▲
ICT	Total	1,455	75.7%	1,101	-46 ▼	-4.0% ▼
	Male	905	72.2%	653	14 ▲	2.2% ▲
	Female	550	81.5%	448	-60 ▼	-11.8% ▼
Mathematics	Total	3,129	88.1%	2,757	-184 ▼	-6.3% ▼
	Male	1,747	86.4%	1,509	-134 ▼	-8.2% ▼
	Female	1,382	90.2%	1,247	-48 ▼	-3.7% ▼
Physics	Total	1,293	80.9%	1,046	-95 ▼	-8.3% ▼
	Male	925	80.2%	742	-72 ▼	-8.8% ▼
	Female	368	82.6%	304	-24 ▼	-7.3% ▼
All subjects	**Total**	**30,684**	**84.3%**	**25,867**	**-678** ▼	**-2.6%** ▼
	Male	**13,546**	**81.6%**	**11,054**	**-426** ▼	**-3.7%** ▼
	Female	**17,138**	**86.4%**	**14,807**	**-257** ▼	**-1.7%** ▼

Source: JCQ, 2016/17
To view this table with numbers from 2015, see Figure 4.15 in our Excel resource.

Figure 4.17 Attainment in selected STEM Advanced Higher qualifications (2016 to 2017) – Scotland

Subject	Total entries	Percentage A to C grade	Number A to C grade	Percentage A grade	Number A grade
Biology	2,252	73.8%	1,662	18.6%	418
Chemistry	2,523	83.3%	2,102	30.1%	760
Computing science	641	70.8%	454	20.3%	130
Design and manufacture	82	53.7%	44	9.8%	8
Engineering science	79	53.2%	42	8.9%	7
Mathematics	3,586	74.5%	2,672	37.2%	1,333
Mathematics of mechanics	272	79.0%	215	53.7%	146
Physics	1,861	78.2%	1,455	29.9%	556
All subjects	**24,112**	**80.0%**	**19,283**	**31.7%**	**7,643**

Source: SQA, 2016/2017
To view this table with numbers from 2016, see Figure 4.17 in our Excel resource.

4.5 – Teacher shortages

The long-standing shortage of STEM teachers continues across the UK, despite many targeted interventions to address this issue. Shortfalls in recruitment and problems with retention both contribute to the continued undersupply of STEM specialist teachers.

In 2017, recruitment targets were missed for the fifth consecutive year in England.[4.56] This shortage does not show signs of improvement: the latest data from the Department for Education indicates that in the year 2017 to 2018, there was a shortfall of 2,188 STEM trainee teachers against their teacher supply model target.

Only 33% of design and technology places were filled in the academic year 2017 to 2018 (down from 41% in 2016 to 2017), as were 68% of physics places (compared with 81% the previous year), and 81% of maths positions (down from 84% the previous year).[4.57] As a result, the number of STEM specialist teachers has remained largely stagnant since 2015, while pupil numbers have grown by nearly half a million between 2011 and 2016.[4.58]

Moreover, evidence shows there is an issue of retention, with teachers increasingly leaving the profession for reasons other than retirement. Of the 117,000 teachers who qualified in England between 2011 and 2015, 23% had left the profession during that time.[4.59] The National Audit Office noted that, among leavers, the proportion leaving for reasons other than retirement rose from 64% to 75% between 2011 and 2014.[4.60] According to recent research, science teachers were the most likely to have considered leaving the profession.[4.61] Rising vacancy rates also suggest higher teacher turnover. The number of full-time teacher vacancies in state-funded schools has risen from 380 (0.1% of the workforce) in 2010 to 920 (0.3%) in 2016 and the number of temporarily filled positions increased from 1,790 (0.5% of the workforce) to 3,280 (0.9%) over the same period.[4.62]

Retention problems are particularly acute for newly qualified science teachers, whom research has shown to be 20% more likely to leave the profession within their first five years than similar newly qualified non-science teachers. For those who hold a physics or engineering degree, the odds of leaving within the first five years jump to 87% higher than similar newly qualified non-science teachers.[4.63] This, in turn, contributes to lessons being taught by non-subject specialists.

The impact of teacher recruitment and retention issues is significant for physics relative to other STEM subjects such as biology and chemistry. In England, there were a thousand fewer physics teachers than chemistry teachers and 2,300 fewer physics teachers than biology teachers in 2016 (Figure 4.18). These differences are particularly pronounced at key stages 4 (GCSE) and 5 (A level).

Figure 4.18 Number of teachers of STEM subjects in maintained secondary schools in England by key stage (2016)

		All teachers	Key stage 3	Key stage 4	Key stage 5
Mathematics		34,400	30,800	28,000	13,800
Physics		6,500	1,600	4,000	4,300
Chemistry		7,500	1,700	4,400	5,300
Biology		8,800	1,800	4,700	6,500
Combined/general science		32,700	29,700	25,300	3,100
Other sciences		2,000	400	800	1,100
Design & technology		11,300	5,700	8,900	2,700
	of which:				
	Electronics/systems and control	800	400	500	200
	Food technology	4,500	2,600	3,300	600
	Graphics	2,800	1,100	190	700
	Resistant materials	3,400	1,500	2,500	500
	Textiles	2,500	1,000	1,800	900
Other/combined technology		13,600	12,500	3,200	2,300
Engineering		1,400	300	1,000	600
ICT		12,400	10,200	7,800	4,400
All subjects		**223,800**	**200,400**	**196,900**	**112,700**

Source: DfE, 2016
To view this table with numbers from 2011, see Figure 4.18 in our Excel resource.
Note: Because teachers may teach more than one subject and at more than one key stage, the sum of rows and columns will not sum to totals.

4.56 House of Commons Education Committee. 'Recruitment and retention of teachers', February 2017.
4.57 DfE and NCTL. 'Initial teacher training: trainee number census - 2017 to 2018', November 2017.
4.58 EEF. 'STEM teacher shortage', July 2017.
4.59 The Guardian. 'Almost a quarter of teachers who have qualified since 2011 have left profession', July 2017.
4.60 NAO. 'Training New Teachers', February 2016.
4.61 NFER. 'Engaging Teachers: NFER Analysis of Teacher Retention', September 2016.
4.62 House of Commons. 'Teacher recruitment and retention in England', January 2018.
4.63 Wellcome Trust. 'Improving science teacher retention: do National STEM Learning Network professional development courses keep science teachers in the classroom?', 2017.

Figure 4.19 Number of registered teachers maintained secondary schools by STEM subject taught, and whether they were trained in that subject (2016 to 2017) – Wales

Subject	Total teaching subject	Percentage known to be trained in subject	Number known to be trained in subject	Change over 1 year (%)	Change over 5 years (%)
Biology	422	58.5%	247	-1.1% ▼	-6.1% ▼
Chemistry	410	51.5%	211	-4.4% ▼	4.5% ▲
Mathematics	1,501	78.8%	1,183	-0.4% ▼	14.1% ▲
Physics	357	46.2%	165	1.9% ▲	-4.1% ▼
Science	1,115	31.7%	354	0.5% ▲	4.1% ▲

Source: EWC, 2012 to 2017
To view this table with numbers from 2012, see Figure 4.19 in our Excel resource.

Figure 4.20 Number of secondary school STEM teachers and proportion who are teaching their main subject (2016) - Scotland

Subject	No. teaching main subject	Percentage teaching main subject	Total no.	Main subject taught–change over 1 year (%)	Main subject taught–change over 5 years (%)
Biology	1,183	87.4%	1,353	1.5% ▲	2.2% ▲
Chemistry	942	84.4%	1,116	1.1% ▲	1.5% ▲
Computing studies	594	69.5%	855	-1.2% ▼	-12.0% ▼
General science	131	7.7%	1,693	2.3% ▲	-7.1% ▼
Mathematics	2,331	94.0%	2,481	-0.8% ▼	-8.0% ▼
Physics	814	90.0%	904	0.9% ▲	-4.2% ▼
All subjects	**21,528**	**73.2%**	**29,398**	**-0.3%** ▼	**-4.6%** ▼

Source: Scottish Government, 2011/2016
To view this table with numbers from 2011, see Figure 4.20 in our Excel resource.

In Welsh secondary schools, only 46% of physics teachers were known to be trained in the subject, suggesting that schools are struggling to fill vacancies with suitably qualified candidates (Figure 4.19). The total number teaching physics changed marginally since 2012 and was also less than the total teaching biology or chemistry. The exception is mathematics, which has seen a modest increase in the number of trained teachers, from 1,097 in 2012 to 1,183 in 2017.

Scotland too had fewer physics teachers than biology or chemistry teachers in its secondary schools. Most notable through, has been the overall reduction in all teachers by 932 between 2012 and 2016 (Figure 4.20). Of these, 173 were mathematics teachers.

Governments across the UK have been taking steps to improve teacher recruitment and retention, although their impact remains unclear at best. Bursaries have been introduced, aiming to attract high-calibre recruits to the profession but, as yet, there is little evidence of their effect (the DfE is due to publish an impact report in April 2018).[4.64] In October 2017, the Government announced that it would pilot a student loan reimbursement programme for science and modern foreign language teachers in the early years of their careers.

Moreover, there are new and ongoing campaigns in the science and engineering community to attract more people to train or retrain as science teachers, such as the engineering scholarships offered by the Institute of Physics, which offer financial and professional support.[4.65]

The evidence reviewed in this section suggests that it is crucial that the government, engineering industry, and education sector work together on innovative approaches to incentivise talent into the teaching profession. Further work is also needed to improve retention of specialist STEM teachers. In particular, the multiple-year failure to meet recruitment targets in design and technology and teaching capacity shortages at A-Level physics deserve particular attention.

4.64 House of Commons Education Committee. 'Recruitment and retention of teachers', February 2017.
4.65 IOP. 'Engineers into teaching'.

UTCs: Progress and Prospects

Where is the UTC programme now?

We all know about the skills shortage. There were 209,500 reported Skills Shortage Vacancies in 2015, up 43% from the 146,000 reported in 2013 (Employer Skills Survey 2015). The Brexit decision is expected to make this worse.

University Technical Colleges can only play a small part in solving this problem themselves. But hopefully, as they become better known in the English schools' system, UTCs will, by example, encourage other schools to take the skills shortage more seriously.

The UTC programme started in 2010. There are now 49 open UTCs. They combine a rigorous academic and technical education and their curriculum reflects local employers' requirements. They are located all over England where employers are ready to make the major commitment to govern them and to work with our students on projects. Around £500 million of taxpayers' money has been invested in the programme to date.

Our insistence on a 14 to 19 age range and clear focus on technical education means that we do not sit easily within an essentially monolithic school system. However, when the present UTCs are full, we will only be educating some 28,000 pupils, or approximately 2% of the entire cohort. We will be doing this at a time when mainstream schools attach ever less importance to creative and technical subjects. Total GCSE entries in this area have fallen by 21%, or 140,000, between 2010 and 2016.

University Technical Colleges®

Charles Parker

Chief Executive
Baker Dearing Educational Trust

There has been no material improvement in the international rankings of the English schools system since 2006. We may be getting better, but only at the same speed as our competitors. There continues to be an even greater focus on academic qualifications and on written formal exams. Coursework is out of favour. This underpins the Ofsted inspection regime. No account is taken of the more technical subjects. There is very little emphasis on student destinations and indeed on the essential project-based learning that is at the core of our UTCs.

Nonetheless, the UTC programme is establishing itself in a small corner of the education system. UTCs continue to have an age range of 14 to 19, which is essential for these reasons:

- the age of 11 is too young for a child to be asked to specialise
- the long school day that UTCs operate is too demanding for students aged 11-13 in what is known as key stage 3
- UTCs cannot teach the broad curriculum required at key stage 3
- employers and students tell us how much they value the adult feel in a UTC community, where the average age of the students is around their 17th birthday

Are we turning the corner?

There are very positive signs for the UTC programme at present. In July 2017, we had excellent destinations for our 18 year olds for the third year running. Forty-six per cent of our leavers went to university, compared to a national average of 51%. Twenty-nine per cent started apprenticeships and, on average, they started at of one level above those from normal

The Technical and Further Education Act 2017 means that UTC Principals will have the legal right to enter schools to tell students at the end of key stage 3 about the opportunities at UTCs.

Only 5 of the 1,900

18 year olds who left us last year were on Job Seekers Allowance

schools. Seven per cent of UTC leavers started work. Eight per cent stayed in education. Of the 1,900 18 year olds who left us last year, we could only find 5 on Job Seekers Allowance, whereas the average figure for NEETs at this age is around 12%.

Employers are the defining characteristic of UTCs. There are 500 actively involved and they are engaging much more readily with UTCs across England now that they can see what UTCs can produce.

On the other hand, we cannot yet say that UTCs are succeeding by normal school standards. We are, on average, 50% full, as our insistence on an atypical age has made recruitment difficult.

Ofsted has inspected 24 open UTCs, and only half are rated at good or better. It is a huge challenge to start up new schools so different from the mainstream and Ofsted has come too early in many cases.

UTCs have been established without financial reserves, which makes it hard for them to cope with short term fluctuations in their operations, leading to financial stress in some cases.

Finally, the emergence of T Levels may pose a problem for UTCs, if the idea that institutions should not be allowed to offer a blend of academic and vocational qualifications is carried over into the fine detail. UTCs need to offer good quality academic education and good quality technical education in the same place.

UTC applicants for year 10 increased by 9% between 2016 and 2017.

Reasons for optimism

The government has recently been much more helpful. It introduced a new law in 2016 that requires local authorities to write to the parents of every child at the end of key stage 3, advising them of the existence of a UTC within an hour's travelling time. Children have approached us from local authorities that we had not heard from before. In September 2017, this was converted into a 9% increase in applicants for Yr10, which is very encouraging for the future and puts us on just under 60% capacity utilisation.

The Technical and Further Education Act 2017 also means that, with effect from January 2018, UTC Principals will have the legal right to enter schools to tell students at the end of key stage 3 about the opportunities at UTCs. This will be one of the most important developments in careers advice and guidance for several years.

UTCs have also been exempted from the English Baccalaureate, which would have made it very difficult for many of them to offer the focussed technical curriculum that our students and employers require.

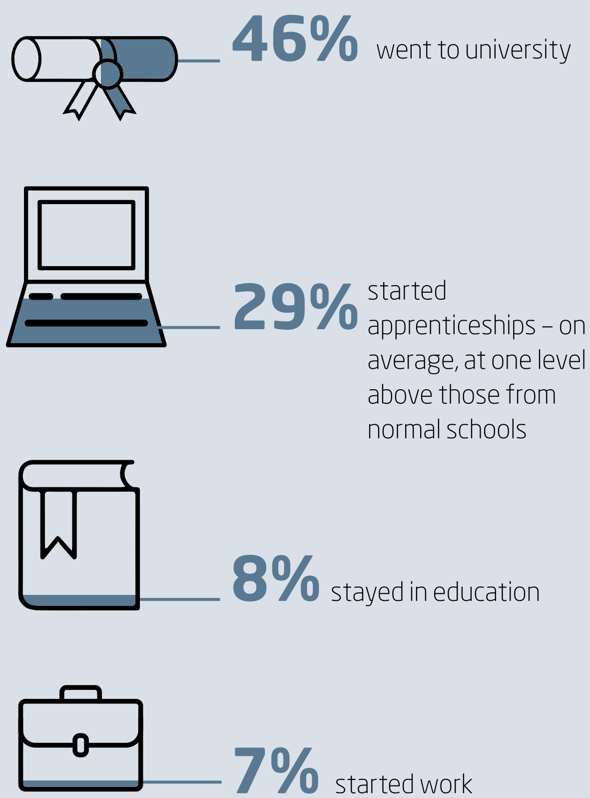
Our next priority is to develop a channel through which able individuals can be trained or retrained to teach the engineering curriculum that our students so desperately need.

Where is the programme likely to be in two years' time?

The coming months will be pivotal for the UTC programme. The exam results, student recruitment, and the excellent destinations mean that we may at last have proved the UTC concept. This does not mean that UTCs will ever be at the mainstream of English education. But they should become a highly valued pathway for a minority of students who at the age of 14 know roughly where their interests lie.

Perhaps the most significant development over the next two years will be at the level of the teaching staff. There remains a critical shortage of engineering teachers. Once Baker Dearing can embed the UTC programme in the English schools system, our next priority is to develop a channel through which able individuals can be trained or retrained to teach the engineering curriculum that our students so desperately need. We will imitate other European countries and seek to persuade qualified engineers to retrain as teachers, perhaps while retaining a part time role in their place of work. This will complete the crossover, which in UTCs is functioning at the level of the governing body and the students. It now needs to extend to the staff room.

Destinations of UTC leavers



5 - Apprenticeships and further education

24% of all apprenticeship achievements in the academic year 2015 to 2016 were in an engineering-related sector

Engineering-related apprenticeship achievements in (2015 to 2016)
England: 63,780
Scotland: 5,639
Wales: 3,690

Key points

Policy reform

Policy reform in England continues with new apprenticeship standards, degree apprenticeships and the introduction of an apprenticeship levy on employers with a salary bill exceeding £3 million. The UK government intends new, employer-led apprenticeship standards to lead to greater status and take up. In summer 2017, 160 new apprenticeship standards were ready for delivery, 83 in the engineering footprint.

The new apprenticeship levy, which started in April 2017, has raised concerns. The government will not spend all of the funds raised by the levy on apprenticeships, which may lead to the perception of the levy as a tax, and employers may not be able to take advantage of the apprenticeship vouchers.

There is also concern that some employers may reconfigure existing training into apprenticeships, so that rather than encourage expansion, public funding will subsidise existing training. Combined with the UK government target for 3 million starts by 2020, the levy could result in a compromise in quality.

Increasingly, the government has focused on apprenticeships at higher levels, amid concerns that much of the initial growth has been in low-cost areas and typically leading to level 2 qualifications.

The first degree apprenticeships have been successfully completed in England and graduate level apprenticeships have run in Scotland. They appear to be supported by older (Russell Group) and newer universities. Anecdotal evidence from employers indicates positive take up of degree apprenticeships, in order to combine the advantages of apprenticeship and degree recruitment programmes. Many of the new degree apprenticeship programmes are within the engineering footprint and lead to professional registration.

Apprenticeship participation

Employer participation in apprenticeships has continued to increase. 262,500 employers in England employed apprentices in the academic year starting 2015, a 4.5% increase in the number who did so the previous year.

Encouragingly, engineering-related apprenticeships also appear to have grown in popularity. In England, the number of apprenticeships starts in the academic year 2015 to 2016 increased by 7.4% over the year before, and in Scotland by 6.8%. The year-on-year increase was even higher in Wales, at 7.8%. However, initial figures from 2017 suggest apprenticeship starts are dropping. This decline has coincided with the introduction of the apprenticeship levy.

Apprenticeship achievements

In the academic year 2015 to 2016, the number of people achieving success in engineering-related apprenticeships in England grew by 9.3% over the previous year, more than double the rate observed across all subject sector areas (4.1%). This difference was even more pronounced in Scotland, where engineering-related apprenticeship achievements saw an increase of 5.6% over the year before, compared with 2.2% overall. In Wales, however, both engineering-related apprenticeship achievements and achievements overall fell in the academic year starting 2015 relative to the previous year (by 8.7% and 21.0%, respectively).

Diversity issues

Women were acutely underrepresented among those starting engineering-related apprenticeships in the academic year 2015 to 2016. In England, just 8.1% were female, and the proportion was even lower in Scotland, at 3.8%. Although apprenticeship data in Northern Ireland is not available by starts, figures show women were similarly underrepresented among those on engineering-related apprenticeships generally (7.8%). In all nations, particularly marked female underrepresentation could be observed within some specific frameworks. For example, in Northern Ireland just one of 708 electrotechnical apprentices was female in 2016.

Ethnic diversity was also low among engineering-related apprentices. This is particularly striking given that people from black and minority ethnic (BME) backgrounds are well represented among engineering and technology students in higher education. In the academic year starting in 2015, the proportion of people from BME backgrounds achieving an apprenticeship across all sector subject areas in England exceeded one in 10 for the first time. However, engineering-related sector subjects lagged behind, with only 6.7% of English achievements by people identifying as BME.

Further education colleges

College sustainability and rationalisation has led, so far, to fewer mergers than initially expected, but the number of colleges has continued to decrease. The UK government's new specialist national colleges are now taking shape, with four of the five colleges now open and delivering courses. The previously announced institutes of technology are expected to open in 2018 and may be based at existing further education colleges.

In 2016, 3.7 million vocational qualifications were awarded across all subjects in England, Wales and Northern Ireland. Of those, 490,695 were in engineering-related sector subject areas.

About the data

Analysis in this chapter is based on data drawn from a number of sources but primarily the FE data library and the Skills Funding Agency. Numbers are rounded to the nearest 10 or 5 depending on the source. Percentages and numbers may not sum to 100% or the total due to rounding errors or because missing or unknown categories have not been included in the figures.

Ideally we would provide data over 5 years (2010 to 2011 to 2015 to 2016). However, because comparable data is often not available from 2010 to 2011, we have shown trends over four years from 2011 to 2012. For Scotland we have changed from showing data for the fourth quarter only to data from the whole year from 2014 to 2015 up to 2015 to 2016.

More tables are available in the Excel resource.

5.1 – Post-16 Skills Plan

Further education remains at something of a crossroads, with major changes to the technical policy landscape underway. This has largely been driven by recognition of the skills shortage and the "… current system of technical education [having] some serious flaws."[5.1] These flaws include the low qualification value of many apprenticeships (as highlighted in the 2011 Wolf Report),[5.2] a lack of availability and the complexity of the system for learners to navigate.[5.3] In 2016, an independent panel on technical education (the Sainsbury review)[5.4] was highly critical of the "over-complex" existing system, which it saw as "fail[ing] to provide the skills most needed." The panel provided a series of recommendations to simplify the number of technical routes available. Notably, these reforms have a clear economic impetus: addressing the shortage of highly skilled people will increase productivity, expanding the economy and improving the UK's international competitiveness.

Apprenticeships are seen as a key way to raise skills levels in the workforce (see **Chapter 10**). They also provide a route out of youth unemployment and, therefore, can promote greater social mobility.[5.5] There is evidence that apprentices enjoy a much higher employment rate than young people without qualifications. What's more, apprentices earn more over their working life than those who have A levels as their highest qualification.[5.6,5.7]

The recommendations of the Sainsbury review were accepted by the government "unequivocally, where that is possible within existing budgets," and have become the basis for the Post-16 Skills Plan.[5.8] The plan includes putting a common framework of 15 technical education routes in place for college-based and employment-based learning (**Figure 5.1**), laying out a general academic route and a technical route post 16, and enabling apprentices to transition between the two (although it is not specified how this last point will be achieved). Transition years are also to be offered to those who are not ready to start a technical education route at 16. The transition year is expected to be tailored to individual students' prior attainment and aspirations, while still emphasising basic skills and progression (particularly in mathematics and English).

On paper, this presents a clearer delineation between academic and technical education, with learners working towards A levels or 'T levels': until now, the boundary between academic and vocational qualifications has been indistinct. However, it was reported in March 2017 that the Department for Education would retain applied general qualifications (including BTECs and OCR's Cambridge Technicals series), which sit between the two pathways.[5.9] A middle route between A levels and T levels may therefore remain. In addition, it appears that extensive discussions around ensuring that technical routes are held in equal esteem to academic routes have not succeeded. An equalities impact assessment published by government indicated that, at least at upper secondary level, A levels will continue to have higher status.[5.10]

The equalities impact assessment also highlighted that those taking a technical route through education are more likely to be male, of Caribbean ethnicity, have special educational needs and/or a disability, and be eligible for free school meals. Later in this chapter we look at apprenticeship achievements by ethnicity. In 2015 to 2016, black African, black Caribbean and black British groups were underrepresented in engineering-related apprenticeships. This raises concerns for progression in the proposed technical education route for these groups.

Figure 5.1 The 15 technical education routes in the Post-16 Skills Plan

Route	Aligned to the engineering footprint
Agriculture, environment and animal care	
Business and administrative	
Catering and hospitality	
Childcare and education	
Construction	Y
Creative and design	
Digital	Y
Engineering and manufacturing	Y
Hair and beauty	
Health and science	
Legal, finance and accounting	
Protective services	
Sales, marketing and procurement	
Social care	
Transport and logistics	

Source: Institute for Apprenticeships 2017

5.1 HM Government. 'Post-16 Skills Plan', 2016, p.11.
5.2 Wolf A. 'Review of Vocational Education – The Wolf Report', BIS, 2011.
5.3 HM Government. 'Post-16 Skills Plan', 2016, p.11.
5.4 Sainsbury D. 'Report of the Independent Panel on Technical Education' (Sainsbury Review), 2016.
5.5 Gloster R and others. 'The contribution of Further Education and skills to social mobility', BIS, 2015.
5.6 Kirby P. 'Levels of Success: the potential of UK apprenticeships', Sutton Trust, 2015.
5.7 IPPR. 'Learner Drivers: Local Authorities and Apprenticeships', 2015.
5.8 HM Government. 'Post-16 Skills Plan', 2016, p.11.
5.9 FE Week. 'Government decides to retain Applied General qualifications', March 2017.
5.10 BIS, DfE. 'Technical education reform: assessment of equalities impacts', 2016.

5.2 – Apprenticeship reforms

Because education is devolved to the administrations/governments of Scotland, Wales and Northern Ireland, there are four apprenticeship systems in the UK. **Figure 5.2** below shows the types of apprenticeships by level and country.

Recent apprenticeship frameworks (and new apprenticeship standards) can occupy different levels, from intermediate apprenticeships at level 2 (roughly equivalent to 5 GCSE passes) upwards (**Figure 5.2**). Advanced apprenticeships are level 3 frameworks, which broadly equate to two A level passes, while higher apprenticeships are at level 4, although these constitute a small fraction numerically of all apprenticeships.

Crucially, the Post-16 Skills Plan seeks to build on existing apprenticeship reforms that are already underway in England. In 2015, the government published *English apprenticeships: our 2020 vision*. This outlined how it intended to increase the quantity and quality of apprenticeship training and employer involvement by establishing the Institute for Apprenticeships, introducing apprenticeship standards and an employers' levy, and setting key targets around participation.[5.11]

Perhaps inevitably, these changes have been met with some confusion and varying degrees of protest from stakeholders.[5.12] While it is too early for system-level results which would make a full assessment of the impact of these reforms possible, there are indications of its reception. These are explored in the remainder of this section.

Apprenticeship standards

Since 2014, the Institute for Apprenticeships, a non-departmental public body sponsored by the Department for Education, has been working with groups of 'trailblazer' employers to develop new apprenticeship standards for different job roles. These trailblazer groups are organised by occupation and include a large number of employers whose sectors are within the engineering footprint. (Indeed, some of the case studies in this report are by employers who are also trailblazers.) Each apprenticeship standard has an assessment plan produced by these employer-led groups, which are then published by government for employers and training organisations to use. As of November 2017, a total of 355 standards were ready for delivery. In the engineering and manufacturing, construction, and digital groups of standards, 165 standards had been approved for delivery, with 149 remaining.[5.13]

These standards include the key knowledge, skills and behaviours required for an occupation. Unlike the old SASE frameworks (specification of apprenticeship standards for England), qualifications are not mandatory, unless they are degree apprenticeships. However, mathematics and English must be included and specified at the level required for the occupation of the apprenticeship. In another change from the SASE frameworks, independent endpoint assessment is required to confirm that the apprentice is fully competent in the occupation they are employed in. This must use two

Figure 5.2 Apprenticeship types by nation and qualification level – UK

RQF CQFW	England		Wales		Northern Ireland	Scotland		SCQF	Equivalent qualifications
								12	
8	Higher apprenticeships	Degree apprenticeships	Higher apprenticeships	Degree apprenticeships	Higher level apprenticeships	Professional apprenticeships		11	Doctoral degrees
7	Higher apprenticeships	Degree apprenticeships	Higher apprenticeships	(Degree apprenticeships)	Higher level apprenticeships	Professional apprenticeships	Graduate-level apprenticeships	10	Master's degrees
6	Higher apprenticeships		Higher apprenticeships		Higher level apprenticeships	Technical apprenticeship		9	Bachelor's degrees
5	Higher apprenticeships		Higher apprenticeships		Higher level apprenticeships	Technical apprenticeship	Graduate-level apprenticeships	8	Foundation degrees
4	Higher apprenticeships		Higher apprenticeships		Higher level apprenticeships	Modern apprenticeships		7	HNC
3	Advanced apprenticeships		Apprenticeships		Level 3 apprenticeships	Modern apprenticeships	Foundation apprenticeship	6	A Level, Higher
2	Intermediate apprenticeships		Foundation apprentceship		Level 2 apprenticeships	Modern apprenticeships		5	GCSE, National 5
1	Traineeships		Traineeships					4	

Sources: National Apprenticeships Service, Skills Development Scotland, Careers Wales, nidirect, 2017.
RQF – Regulated Qualifications Framework, CQFW – Credit and Qualifications Framework for Wales, SCQF – Scottish Credit and Qualifications Framework

5.11 BIS. 'English Apprenticeships: Our 2020 Vision - Executive Summary', 2015.
5.12 See, for example: CIPD. 'Apprenticeship levy dubbed stealth tax following IFS report', 2017.
5.13 IFA. 'Apprenticeship Standards', 2017.

distinct methods, such as tests, viva or professional discussion, workplace observation, workplace projects, or portfolios. In addition, assessments must be conducted by an assessment organisation registered with the Education and Skills Funding Agency.[5.14, 5.15]

In 2015, the government committed to increasing the number of apprenticeship starts in England to three million by 2020.

Each apprenticeship standard is also now required to have External Quality Assurance (EQA). There are four options: employer-led, professional bodies, Ofqual and Institute for Apprenticeships.[5.16] At the time of writing, there is also a requirement for 20% of training to be 'off the job'. This has been met with some resistance from employers, who argue that the proportion of off-the-job training should be set by each trailblazer group. [5.17]

Meanwhile, apprenticeship frameworks under the old SASE framework have been withdrawn in successive batches and so are no longer available to new starters. Stakeholders have expressed concern over the scale and pace of change in transitioning from 228 SASE framework to 600 occupation standards developed by trailblazer employer groups.[5.18] While the government has announced that the target to phase out the remaining SASE frameworks by 2020 remains, the fourth batch to be withdrawn has been delayed.[5.19]

Apprenticeship levy

In 2015, the government committed to increasing the number of apprenticeship starts in England to three million by 2020.[5.20] To fund these new apprenticeships, and to "put employers at the centre of the system", the government introduced the Apprenticeship Levy in April 2017. This required employers with annual salary bills in excess of £3 million to pay a levy equivalent to 0.5% of that bill.[5.21] The government estimates that the levy will enable it to double investment in apprenticeships by 2020 compared with 2010, to £2.5 billion.[5.22]

The apprenticeship levy [5.23, 5.24, 5.25]

- started 6 April 2017
- applies to employers (individual or connected companies) in England with a pay bill (all payments to employees subject to class 1 secondary National Insurance contributions) of over £3 million a year:
  - includes all employees aged at least 16 earning below the Class 1 National Insurance thresholds
  - includes employees aged under 21 and apprentices aged under 25
  - where the employer has employees living in Scotland, Wales or Northern Ireland as well as England, the pay bill is calculated on the percentage of employees living in England
- employers who contribute to the Construction Industry Training Board levy still have to pay the apprenticeship levy
- includes schools via either their governing body or the local authority (if their pay bill is over £3 million)
- collected each month through the HMRC Pay as You Earn process
- amounts to 0.5% of the annual pay bill, minus £15,000 allowance
- employers can spend their contribution with an approved apprenticeships training provider for training and assessment, via an online apprenticeship service account (employer must cover wage costs themselves)
- the government will give a 10% top up each month to the funds in the apprenticeship service account
- funds that aren't used within 24 months will expire (the oldest funds are automatically taken each time a payment is made)
- employers who are not eligible to pay the levy can share the cost of training and assessing their apprentices with the government ('co-investment'), with the government paying 90%, up to funding band maximums

5.14 IFA. ''How to' guide for trailblazers', 2017.
5.15 The Education and Skills Funding Agency replaced the Skills Funding Agency and the Education Funding Agency in April 2017. It includes the National Apprenticeship Service.
5.16 IFA. 'How to' guide for trailblazers', 2017.
5.17 AELP. 'Off-the-job training: Employers say one size does not fit all. Employers and providers call for a review of arbitrary 20% measure', 2017.
5.18 HM Government. 'Information about the withdrawal of apprenticeship frameworks', October 2017.
5.29 FE Week. 'Government delay to framework removals AELP welcomes news', August 2017.
5.20 BIS. 'English Apprenticeships: Our 2020 Vision - Executive Summary', 2015.
5.21 HMRC. Apprenticeship Levy, February 2016.
5.22 DfE. 'Apprenticeship funding: how it will work', July 2017.
5.23 DfE. 'Apprenticeship funding: how it will work', 2017.
5.24 Milton, A. 'Future of the Construction Industry Training Board' (Letter), July 2017.
5.25 HMRC. 'Pay Apprenticeship Levy', February 2017.

The levy has had a more immediate impact on employers than the new apprenticeship standards. Unsurprisingly, it is this aspect of apprenticeship reforms that has triggered most protest amongst employers. While the government announced that it would only affect 2% of employers, by definition these employ large numbers of staff (hence the wage bill of over £3 million). The Institute for Fiscal Studies has estimated that 63% of employees work for large employers who are likely to be subject to the levy.[5.26]

It's not just those businesses who have to pay the levy who are concerned. Non-levy payers and training providers are also concerned about changes to their funding. These may turn out to be teething issues. However, early implementation does not appear to be entirely smooth. A key indication of success will be whether these lead employers to commit to more apprenticeships – or whether they find creative ways to re-label existing education and training so that they can access the levy. In their 2017 education and skills survey, CBI and Pearson reported that nearly two-thirds (63%) of over 340 businesses surveyed from February to April 2017 planned to "reconfigure their existing training into apprenticeships."[5.27] This risk of relabelling was identified by the Institute for Fiscal Studies in February 2017[5.28] and by the House of Commons Public Accounts Committee in November 2016, who also saw that it might be abused to avoid paying the minimum wage.[5.29]

Furthermore, the Institute of Fiscal Studies warned that any rapid expansion of apprenticeships, encouraged by both the government target and the levy, may compromise the quality of those apprenticeships. This is a particular concern when the Institute for Apprenticeships is already under pressure to increase the number of apprenticeship standards available.[5.30]

At the time of writing, the operation of the levy is still in its first few months of operation, and the effects of the levy itself on the supply of skilled people to work in the engineering sectors remains to be seen. The first provisional figures on starts show a decrease of 61% for all sector subject areas.[5.31] Anecdotal reports indicate that there was an increase in starts under the old funding arrangements and a corresponding drop after the introduction of the levy.[5.32] However, this pattern is typical when a vocational qualification or funding arrangement is withdrawn and replaced, and so is not that informative.

There are indications that the apprenticeship levy may not be wholly successful in helping to achieve the government's target of 3 million apprenticeship starts in total by 2020. City & Guilds has estimated that there is potential in the UK market for 630,000 apprentices a year across all sectors by 2019 to 2020, which is approximately 130,000 more than now.[5.33] One survey of employers by the Association of Employment and Learning Providers found that just 17% planned to increase the number of apprentices within the next 7 months and 35% intended to reduce it. Looking beyond October 2017, just over one-fifth (22%) expected an increase and the same (22%) a decrease. However, levy payers and large employers noted they were more likely to plan to increase apprenticeship numbers.[5.34] The CBI's report, which surveyed approximately 340 employers, found that 46% expected to increase the number of apprenticeship places.[5.35] More (63%) expected to reconfigure existing training into apprenticeships. They also expected to save costs elsewhere, with over one-fifth (23%) of employers surveyed expected to reduce the number of graduates they would recruit. Over one-quarter (27%) expected to cut training that was not related to apprenticeships.

One further, unintended, consequence of the current levy policy is that council maintained schools, including small schools, may be liable to pay a share of the levy bill.[5.36] This will have to be covered from school budgets that are already stretched. This has been highlighted, by the Local Government Association but the Department for Education has not indicated that it will either amend this policy or adjust school funding accordingly.[5.37]

Concerns have also been expressed about the new apprenticeship funding system, which was introduced in May 2017. Under this new system, available funding has been structured into bands that differ by occupation, with each band representing the maximum amount the government will provide towards the off-the-job training and assessment costs. The bands are also intended to provide a reference point for negotiations between employers and training providers.[5.38] The Institute for Fiscal Studies has warned that this funding band arrangement will lead to providers pricing towards the top of each band, with little incentive for employers to negotiate down (as they will not see the saving).[5.39] A lower price for training may also be interpreted as an indication of lower quality, leading to poorer value for money. Notably, 26 of these bands have been increased under the new system, including those for composite engineering, and various pathways in engineering manufacture and manufacturing engineering (from £9,000 to £12,000). Three have been decreased, including for engineering manufacture aerospace from £12,000 to £9,000.[5.40]

In the same Institute for Fiscal Studies report, it is observed that the levy would raise an estimated £2.6 billion in 2017 to 2018, increasing to £2.8 billion in 2018 to 2019. Yet much of this increase in revenue will not be used to fund apprenticeships. This may lead to a perception among employers that the levy is a stealth tax rather than a means to increase the number of apprentices. Employers at a January 2017 meeting of EngineeringUK's Business and Industry panel, for example, indicated they expected to recoup only 20% of their levy spend.[5.41]

5.26 IFS. 'IFS Green Budget 2017': Chapter 8, Reforms to apprenticeship funding in England, January 2017.
5.27 CBI. 'Helping the UK Thrive: CBI/Pearson education and skills survey 2017', July 2017, p.67.
5.28 IFS. 'IFS Green Budget 2017': Chapter 8, Reforms to apprenticeship funding in England, January 2017.
5.29 House of Commons Committee of Public Accounts. 'The apprenticeships programme: Twenty-eight Report of Session 2016-17', November 2016.
5.30 IFS. 'IFS Green Budget 2017': Chapter 8, Reforms to apprenticeship funding in England, January 2017.
5.31 FE Week. 'First official apprenticeship levy figures show a 61% fall in starts,' October 2017.
5.32 FE Week. 'Festival of Skills: Apprenticeship starts 'a quarter' of what they were before May'. FE Week, June 2017.
5.33 City & Guilds. 'The apprenticeship reforms: back to basics', February 2016.
5.34 Warwick IER. 'The Impacts of the Apprenticeship Levy: Findings from the employer survey', 2017.
5.35 CBI. 'Helping the UK Thrive: CBI/Pearson education and skills survey 2017', July 2017.
5.36 TES. 'Apprenticeship levy will hit small schools due to 'archaic' system', November 2016.
5.37 LGA. 'Small council-maintained schools should be exempt from Apprenticeship Levy', January 2017.
5.38 DfE. 'Apprenticeship funding: how it will work', July 2017.
5.39 IFS. 'IFS Green Budget 2017': Chapter 8, Reforms to apprenticeship funding in England, January 2017.
5.40 FE Week. 'ESFA revises 29 apprenticeship framework funding rates', August 2017.
5.41 EngineeringUK. 'Business and Industry Panel lunch: Apprenticeships House of Commons', February 2017.

Case study - The apprenticeship levy and degree apprenticeships

Nicola Anderson, Head of Apprentice Development, Thales

Thales has offered degree apprenticeships since our pilot programme in 2015, which saw 5 learners join as software apprentices within the defence business. Delivered in partnership with Manchester Metropolitan University, this was a 4 year degree working towards a BSc in Digital and Technology Solutions. Since that time, we have seen substantial growth in our degree apprenticeship offering, with 51 learners now enrolled across engineering and business management programmes. This growth, although partly in response to the levy, has been driven primarily by the business benefits that we have seen over recent years.

Degree apprenticeships are high value, enabling us to use up to £27,000 of our levy vouchers to finance a degree for each learner. Trailblazer standards are employer led, empowering us to shape the degrees for our business. Learners are engaged and loyal, and able to apply their university learning directly into the workplace. Taking all this into account, we have taken the strategic approach to push our graduates up the food chain, creating space for degree apprentices to fill our entry level roles. We are also using level 6 and 7 programmes to upskill our existing workforce, while maximising the apprenticeship levy. We also see the effect that an apprentice can have on the wider team, as they bring in fresh thinking and new ideas from their studies that the whole team can benefit from.

All apprentices join as permanent employees from day one and are very much part of our wider succession planning for each job family across the company. Thales will continue to support and invest in apprenticeships as an important, credible and effective entry level talent pipeline into our business.

5.3 – Degree apprenticeships

Increasingly, the government has focused on apprenticeships at higher levels, amid concerns that much of the initial growth in apprenticeship activity has been in low-cost areas and typically leading to level 2 qualifications. There has also been concern that much of the growth has been in retail, healthcare and business generally, whereas the greatest need for apprenticeships in STEM and engineering sectors is thought to be at level 3 and above, which is considerably more costly for employers. Analysis by the Institute for Employment Research, for example, estimates that the cost to an employer of delivering a level 3 apprenticeship could be as high as £40,000, which could take a further 3 years of employment to recoup.[5.42]

In particular, there has been a policy drive towards 'degree apprenticeships', which were announced as a concept in late 2014. A degree apprenticeship combines aspects of both higher and vocational education, and is designed to test occupational competence and academic learning. This can be through a fully-integrated degree programme (co-designed by employers and HE institutions) or a degree plus a separate test of professional competence. Due to the integrated degree qualification, degree apprenticeships are expected to prove highly attractive to students who may be concerned about the debt inherent in a student loan that they are likely to have to take out to fund a university degree.

It is already evident that degree apprenticeships are attractive to HE institutions, and many have invested considerable energy and resources into developing their provision.[5.43] In October 2016, 60 of 66 HE institutions (91%) surveyed by Universities UK across England indicated they were offering degree apprenticeships in the academic year 2017 to 2018. The primary benefits identified by the institutions for their own organisations were:

- increased business engagement
- widening HE participation and increasing social mobility
- delivering HE provision that develops the skills required by employers
- providing an offer to students where fees are paid by employers and government
- access to a new student market and a new income stream

The challenges involved in offering degree apprenticeships were seen as less significant than the benefits, but centred on lack of awareness among individuals, lack of available standards in key occupational areas and uncertainty of employer demand. These may be addressed as more degree apprenticeships become available for delivery and more people become aware of this new route.

The HE institutions that are offering degree apprenticeships included a mixture of older (Russell Group) and newer universities spread across the English regions, suggesting that the concept has been embraced across the sector. Similarly, the Universities UK survey indicated they are growing in popularity among students. The number of learners on degree apprenticeships across the institutions surveyed was reported to have grown for all occupations from 640 in 2015 to 2016, to 2,121 in 2016 to 2017, and is expected to reach 4,850 in 2017 to 2018. The survey was conducted before the introduction of the apprenticeship levy, which most HE institutions will now be obliged to pay. This provides further incentive for universities to develop degree apprenticeships, as they can use the funds they must dedicate to apprenticeship training towards these programmes.

Many of the new degree apprenticeships on offer are engineering-focused, including in aerospace, automotive, construction, digital industries, electronic systems and nuclear. The Universities UK survey indicated that among degree apprentices at the institutions surveyed, across the first 3 years, in total one-third were on 'digital and technology solution professional' apprenticeships (2,533 at 33 institutions) and one-fifth on engineering degree apprenticeships (1,491 at 25 institutions). Within the engineering occupations, manufacturing engineer was the most popular, with 613 learners across 10 institutions in total in the first 3 years.

Figure 5.3 shows the degree apprenticeships within engineering that were ready for delivery at summer 2017. Most of these are at first degree/level 6, with only 4 of the 19 at master's/level 7, and the majority are linked to specific institutes for professional registration.

5.42 Warwick IER. 'Employer Investment in intermediate-level STEM skills: How employers manage the investment risk associated with apprenticeships', February 2016.
5.43 UniversitiesUK. 'Degree Apprenticeships: Realising Opportunities', March 2017.

Figure 5.3 Degree apprenticeship standards approved for delivery within the engineering footprint

Subject	Apprenticeship level	Qualifications	Professional registration	Likely duration
Embedded electronic systems design and development engineer	6	Bachelor's degree		3 years
Nuclear scientist and nuclear engineer	6	Bachelor's degree	IEng or RSci	3 to 5 years
Science industry process/ plant engineer	6	Bachelor's degree in Engineering	IEng	
Chartered surveyor	6	Bachelor's degree in Surveying	MRICS	5 years
Civil engineering site management	6	BEng (Hons) Civil Engineering	IEng	3 to 4 years
Aerospace software development engineer	6	BEng or BSc, L4 Dip Engineering and Advanced Manufacturing	IEng	4 years
Aerospace engineer	6	BEng, L2 dip Aerospace and Aviation, L4 Dip Engineering and Advanced Manufacturing	IEng	4 years
Digital and technology solutions professional	6	BSc (Hons) in Digital & Technology Solutions		3 years
Construction site manager	6	BSc (Hons) Construction Management	MCIOB	3 to 4 years
Construction quantity surveyor	6	BSc (Hons) Quantity Surveying	MRICS	3 to 4 years
Construction design management	6	BSc(Hons) Architectural Technology	MCIAT	3 to 4 years
Control/technical support engineer	6	HND or Foundation degree, BSc (Hons) or BEng Engineering	Eng Tech	5 to 6 years
Product design and development engineer	6	HND or Foundation degree, BSc (Hons) or BEng Engineering	Eng Tech	5 to 6 years
Electrical/electronic technical support engineer	6	HND or Foundation degree, BSc (Hons) or BEng Engineering	Eng Tech	5 to 6 years
Manufacturing engineer	6	HND or Foundation degree, BSc (Hons) or BEng Engineering	Eng Tech	5 to 6 years
Process automation engineer	7	MSc degree in process automation	CEng	5 years
Power engineer	7	Master's degree in Engineering	(membership IET, IMechE)	5 years
Defense systems engineer	7	PG Dip	CEng	3 to 5 years
Outside broadcasting engineer	7	PG Dip in Outside Broadcasting Engineering		12 to 18 months

Source: Institute for Apprenticeships 2017

The development and uptake of degree apprenticeships appears to be successful, with Universities UK describing them as being "on the verge of success". [5.44] However, it is too early to provide any analysis of those who have completed a degree apprenticeship because they were only launched in September 2015. By summer 2017, only 11 people have completed a degree apprenticeship, graduating in July 2017. All 11 of these graduates successfully completed a bachelor of science degree at Aston University (with 7 getting a first class qualification) while completing level 6 apprenticeships in digital and technology solutions at Capgemini.[5.45]

Case study – Degree apprenticeships at Arm

Katherine Sharp, Sustainability Communications Manager, Arm

Arm has a global education programme geared to delivering diversity and inclusion, and acquiring talent. As part of this, Arm has recently added a new route into engineering careers at its Cambridge and Manchester sites for A level students. In partnership with the University of Essex, Arm is offering 10 degree apprenticeships, starting in autumn 2017. New entrants will complete a degree in computer science, electronic engineering or a related subject while earning a salary and working at Arm on tasks that support module learning. Fees for degree tuition are covered by the apprenticeship levy.

To ensure a healthy number of applications for these opportunities, Arm advertised the apprenticeships on its careers pages and reached out to local education partners. Applications were reviewed with the aid of a gamification (game-based assessment) stage within the 4 stage recruitment selection process, which ended with a face to face interview. The gamification stage, which was introduced by the Talent Acquisition team, allowed ARM to assess behaviours using a conceptual 'What good looks like' model for the company.

"ARM's partnership with the University of Essex will launch our first degree apprenticeship programme, which aims to inspire and train the next generation of engineers, providing them with the technical skills and experience needed to develop the innovations of tomorrow," said Jim Fallon, director of engineering development, ARM.

5.4 – Apprenticeships in England

Employer participation

Figure 5.4 shows the number of workplaces that employed apprentices (in all sector subject areas) in the academic year starting in 2015 and how this has increased. The number of workplaces employing apprentices in England in 2015 to 2016 increased by 4.5% (over 11,200) compared with the previous year, to a total of 262,500. This increase was relatively evenly spread across all regions, with the lowest rate of 3.4% found in the South West and the highest in the North East at 6.1%. The South West also had the slowest growth of employer participation over the 5-year period to 2015 to 2016, although this was still relatively large at 38.3%. Other regions saw increases of at least 50% across 5 years to the academic year starting in 2015, with the largest increase in London at nearly 80%. However, in terms of numbers rather than proportions, London had just over 24,000 workplaces employing apprentices, the lowest of all regions apart from the North East. In contrast, nearly 44,000 employers in the North West and 37,000 in the South East employed apprentices in 2015 to 2016.

Figure 5.4 Workplaces in England employing apprentices in all sector subject areas by region in the academic year 2015 to 2016, and change over time (estimates)

Region	No.	Change over 1 year (%)	Change over 5 years (%)
North East	16,120	6.1% ▲	50.2% ▲
North West	43,670	3.9% ▲	51.4% ▲
Yorkshire and the Humber	30,650	4.5% ▲	52.6% ▲
East Midlands	25,550	4.6% ▲	50.6% ▲
West Midlands	29,610	4.4% ▲	55.2% ▲
East of England	26,660	4.2% ▲	57.7% ▲
London	24,210	5.6% ▲	79.5% ▲
South East	37,070	4.4% ▲	58.3% ▲
South West	28,990	3.4% ▲	38.3% ▲
England	**262,500**	**4.5% ▲**	**55.7% ▲**

Source: Skills Funding Agency, 2010 to 2011, 2015 to 2016.
To view this table with numbers from 2010, see Figure 5.4 in our Excel resource.

Apprenticeship starts by sector

Across all sector subject areas, just under 510,000 people started apprenticeships in England in 2015 to 2016, making it the third year in a row for which the number increased (Figure 5.5). However, this was 11,200 fewer starts than in 2011 to 2012 (see our Excel resource for time series data). This is below the required average of 600,000 a year needed to meet the government's target of 3 million apprenticeship starts by 2020. The Institute for Fiscal Studies has expressed concern that this target may be unrealistic. It notes that, given the number of 18 year olds in England, "...unless a significant number of individuals undertake multiple apprenticeships in the course of their career, a long-run target of 600,000 apprenticeships per year is unsustainable, as it would mean about 90% of young people in England taking an apprenticeship at some point".[5.46]

In this context, it is therefore notable that the 3 engineering-related subject areas –construction, planning and the built environment; engineering and manufacturing technologies; and information and communication technology – have (unlike the starts for all sector subject areas) surpassed the levels of apprenticeship starts seen in 2011 to 2012. In 2015 to 2016, there was a 7.4% increase in the number of apprenticeship starts across these areas (to just under 116,000) compared with the previous year, and a 13.5% rise since 2011 to 2012. They have also increased as a proportion of all apprenticeship starts, accounting for 22.8% of the total across all subjects in 2015 to 2016, an increase of 3.1% since 2011 to 2012.

5.44 UniversitiesUK. 'Degree Apprenticeships: Realising Opportunities', March 2017.
5.45 ESFA. 'Graduation ceremony takes place for UK's first Degree apprentices', July 2017.
5.46 ESFA. 'Graduation ceremony takes place for UK's first Degree apprentices', July 2017.

Two-thirds of these engineering-related apprenticeship starts were in engineering and manufacturing technologies (67.7%). Construction, planning and the built environment accounted for just under one-fifth (18.5%) and information and communication technology for the remaining 13.8%. While growth in the year up to 2015 to 2016 was relatively modest in the last of these subject areas (2.3%), there was significant growth in the other two. Apprenticeship starts in engineering and manufacturing technologies increased by 6.0% in 2015 to 2016, and in construction, planning and the built environment growth was nearly three times greater (17.3%). This reflects a longer term trend. Since 2011 to 2012, apprenticeship starts in construction, planning and the built environment have increased by over half, while starts in engineering and manufacturing technologies increased by 12.5%. Over the same period, starts in information and communication technology decreased by 13.5%.

Although the number of apprenticeship starts in science and mathematics is much lower, it has also increased since 2011 to 2012. In 2015 to 2016, 500 people began an apprenticeship programme in this subject area, marking a large increase from the previous year (31.6%) and an increase of 130 on the 370 starts in 2011 to 2012.

Figure 5.5 Apprenticeship programme starts in England by sector subject area in the academic year 2015 to 16, and changes over time

	Total number of starts 2015 to 2016	Change over 1 year	Change over 4 years
Construction, planning and the built environment	21,460	17.3% ▲	54.2% ▲
Engineering and manufacturing technologies	78,480	6.0% ▲	12.5% ▲
Information and communication technology	16,020	2.3% ▲	-13.5% ▼
All engineering-related sector subject areas	**115,960**	**7.4% ▲**	**13.5% ▲**
All engineering-related sector subject areas as a proportion of all sector subject areas	*22.8%*	*1.2%p ▲*	*3.2%p ▲*
Science and mathematics	500	31.6% ▲	35.1% ▲
All sector subject areas	**509,400**	**1.9% ▲**	**-2.2% ▼**

Source: Skills Funding Agency, 2011/2012, 2015/2016
To view this table with numbers from 2011 to 2016, see Figure 5.5 in our Excel resource.

Regional differences

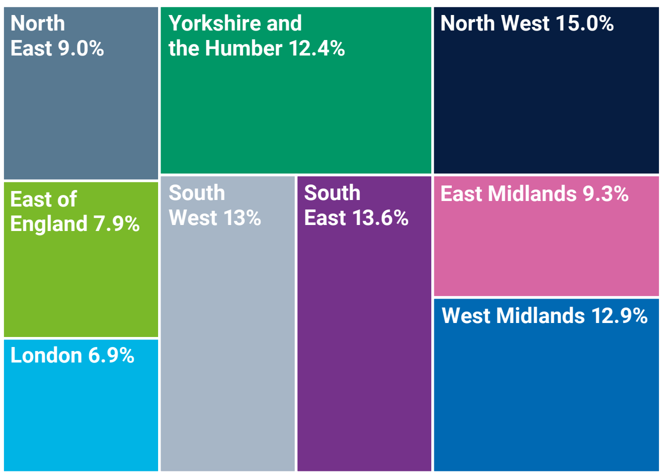
In terms of the regional distribution of apprenticeship starts overall, the North West had the highest proportion (16.0%) and the North East the lowest (7.6%) (Figure 5.7). Yorkshire and the Humber, the West Midlands, and the South East each accounted for around 12% to 13% of apprenticeships starts overall. This proportion was slightly lower for the East Midlands, the East of England, London and South West, at around one-tenth each.

Figure 5.6 shows the distribution of engineering-related apprenticeship starts across England. The North West was also the region with the highest proportion of engineering-related apprenticeship starts (15.0%). The region had a similar proportion of starts in engineering and manufacturing (14.8%) and 17.8% of those in construction, planning and the built environment (Figure 5.7). The comparatively high number of engineering-related apprenticeship starts in the North West may be a reflection of its strong nuclear, automotive and aerospace industry, as well as ship building facilities at Barrow-in-Furness in Cumbria. Additionally, the region benefits from being the site of the Atlantic Gateway, a major infrastructure programme, which is forecast to cost £2 billion to construct and operate over 30 years.[5.47]

Around 1 in 7 (14.2%) of engineering and manufacturing apprenticeship starts were in the West Midlands, a region traditionally associated with engineering. This was slightly more than found in the South East (13.2%), Yorkshire and the Humber (12.6%) and the South West (12.5%). At 5.5% of the total, London had the fewest engineering and manufacturing apprenticeship starts, slightly below the East of England (7.9%).

The regional profile was markedly different for apprenticeships in information, technology and communications, where starts were concentrated in the South West and South East (17.0% each) and lowest in the North East (7.0%) and East Midlands (6.2%).

Figure 5.6 Regional distribution of English engineering-related apprenticeship starts in the academic year 2015 to 2016



Source: Skills Funding Agency, 2015 to 2016

5.47 Mersey Gateway. 'The Mersey Gateway Project', 2012.

Figure 5.7 Apprenticeship programme starts in England by region and sector subject area in the academic year 2015 to 2016

		North East	North West	Yorkshire and the Humber	East Midlands	West Midlands	East of England	London	South East	South West	England total
Construction, planning and the built environment	No.	1,970	3,770	3,020	1,940	1,980	1,760	1,570	2,610	2,600	21,200
	% total	9.3%	17.8%	14.2%	9.2%	9.3%	8.3%	7.4%	12.3%	12.3%	100.0%
Engineering and manufacturing technologies	No.	7,240	11,430	9,790	7,720	10,980	6,120	4,280	10,250	9,670	77,480
	% total	9.3%	14.8%	12.6%	10.0%	14.2%	7.9%	5.5%	13.2%	12.5%	100.0%
Information and communication technology	No.	1,110	1,950	1,340	990	1,870	1,190	2,020	2,690	2,690	15,860
	% total	7.0%	12.3%	8.4%	6.2%	11.8%	7.5%	12.7%	17.0%	17.0%	100.0%
All engineering-related sector subject areas	**No.**	**10,320**	**17,150**	**14,150**	**10,650**	**14,830**	**9,070**	**7,870**	**15,550**	**14,960**	**114,540**
	% total	**9.0%**	**15.0%**	**12.3%**	**9.3%**	**12.9%**	**7.9%**	**6.9%**	**13.6%**	**13.1%**	**100.0%**
Science and mathematics	No.	50	130	70	50	30	60	20	80	20	500
	% total	10.0%	26.0%	14.0%	10.0%	6.0%	12.0%	4.0%	16.0%	4.0%	100.0%
All sector subject areas	**No.**	**38,210**	**80,820**	**63,520**	**48,080**	**60,910**	**46,650**	**46,280**	**65,290**	**54,160**	**503,900**
	% total	**7.6%**	**16.0%**	**12.6%**	**9.5%**	**12.1%**	**9.3%**	**9.2%**	**13.0%**	**10.7%**	**100.0%**

Source: Skills Funding Agency, 2015/2016

Apprenticeship starts by level and gender

Overall, the number of people starting apprenticeships in England has increased over the last five years, but not uniformly by level. As can be seen in Figure 5.8 and additional analysis available in the Excel resource, there appears to be a move towards higher levels. The percentage of starts at level 3+ increased from 36.8% in 2011 to 2012 to 42.8% 2015 to 2016, across all sector subject areas. Higher apprenticeships have enjoyed particularly high rates of growth, rising from 3,700 in 2011 to 2012 to 27,200 in 2015 to 2016 (a 635% increase). Including a peak in 2012 to 2013, and dropping dramatically the following year, the number of advanced apprenticeship starts has grown overall from 2010 to 2011 by 1.6% to 2015 to 2016. However, between 2010 to 2011 and 2015 to 2016, the number of intermediate apprenticeships has fallen by 11.5%.

This trend toward higher level apprenticeships can be observed in the latest figures for which data is available. Between the academic year starting in 2014 and that starting in 2015, the number of intermediate apprenticeship starts in England declined by 2.3%. In contrast, the number of both advanced apprenticeships and higher apprenticeships increased by 5.0% and 37.4% respectively (though the apparent volatility of the latter may in part due to its small base number, as they still represent less than one-tenth of intermediate apprenticeship starts).

Although intermediate apprenticeship starts have increased, growth has been much higher at advanced and higher apprenticeship levels in England.

A similar pattern can be seen in the number of overall engineering-related apprenticeship starts. Although intermediate apprenticeship starts have increased rather than decreased from 2011 to 2012, growth has been much higher at advanced and higher apprenticeship levels. In the academic year 2015 to 2016, 41.9% of engineering-related starts were at level 3+, similar to the proportion of all sector subject areas (42.8%).

However, this average masks some variation within the 3 engineering-related sector subject areas. For example, the proportion of ICT apprenticeship starts that were at level 3+ (76.5%) was over 3 times the proportion of level 3+ starts in construction, planning and the built environment (22.3%). The former has increased from 54.6% at level 3+ in 2011 to 2012 while thelatter has remained broadly static. Within engineering and manufacturing, 40.2% of starts were level 3+, slightly below the average of all sector subject starts, but representing a substantial increase over 2011 to 2012 levels (34.6%).

While the majority of apprenticeship starts in science and mathematics have been, and remain, at level 3+, even here the number of starts at intermediate level has declined while those at advanced level increased. In 2011 to 2012, 75.7% of starts in this subject were level 3+, whereas by 2015 to 2016 this had increased to 88.0%.

Only a minority of people starting engineering-related apprenticeships in England were women (Figure 5.8). While women accounted for over half of all apprenticeship starts (those in all sector subject areas) in 2015 to 2016, less than one in 10 (8.1%) of those starting an engineering apprenticeship were women. This represents, however, a small increase from the previous year (7.5%).

The proportion of women ranged from just 2.2% in construction planning and the built environment to 16.5% in ICT.

Figure 5.8 Apprenticeship programme starts in England by sector subject area and level in the academic year 2015 to 2016, and changes over time

		Total number of starts in 2015 to 2016	Percentage female	Total change over 1 year	Total change over 4 years
Construction, planning and the built environment	Intermediate apprenticeship	16,670	1.6%	15.8% ▲	53.6% ▲
	Advanced apprenticeship	4,510	4.0%	18.7% ▲	46.4% ▲
	Higher apprenticeship	270	11.1%	170.0% ▲	–
	All apprenticeships	21,460	2.2%	17.3% ▲	54.2% ▲
	Percentage level 3+	22.3%	–	*1.0%p* ▲	*0.1%p* ▲
Engineering and manufacturing technologies	Intermediate apprenticeship	46,920	10.3%	5.8% ▲	3.0% ▲
	Advanced apprenticeship	30,900	4.4%	5.5% ▲	28.5% ▲
	Higher apprenticeship	660	12.1%	57.1% ▲	450.0% ▲
	All apprenticeships	78,480	8.0%	6.0% ▲	12.5% ▲
	Percentage level 3+	40.2%	–	*0.1%p* ▲	*5.6%p* ▲
Information and communication technology	Intermediate apprenticeship	3,780	29.4%	-16.2% ▼	-55.2% ▼
	Advanced apprenticeship	10,410	12.9%	5.2% ▲	5.0% ▲
	Higher apprenticeship	1,840	10.9%	47.2% ▲	868.4% ▲
	All apprenticeships	16,020	16.5%	2.3% ▲	-13.5% ▼
	Percentage level 3+	76.5%	–	*5.3%p* ▲	*21.9%p* ▲
All engineering-related sector subject areas	**Intermediate apprenticeship**	**67,370**	**9.2%**	**6.5%** ▲	**3.9%** ▲
	Advanced apprenticeship	**45,820**	**6.3%**	**6.6%** ▲	**23.7%** ▲
	Higher apprenticeship	**2,770**	**11.2%**	**56.5%** ▲	**793.5%** ▲
	All apprenticeships	**115,960**	**8.1%**	**7.4%** ▲	**13.5%** ▲
	Percentage level 3+	**41.9%**	**–**	***0.5%p*** ▲	***5.4%p*** ▲
All engineering-related sector subject areas as a proportion of all sector subject areas	*Intermediate apprenticeship*	*23.1%*	*4.2%*	*1.5%p* ▲	*3.4%p* ▲
	Advanced apprenticeship	*24.0%*	*2.7%*	*-1.6%p* ▼	*4.3%p* ▲
	Higher apprenticeship	*10.2%*	*1.8%*	*-2.0%p* ▼	*1.8%p* ▲
	All apprenticeships	*22.8%*	*3.5%*	*1.2%p* ▲	*3.1%p* ▲
Science and mathematics	Intermediate apprenticeship	60	50.0%	-14.3% ▼	-33.3% ▼
	Advanced apprenticeship	340	41.2%	25.9% ▲	21.4% ▲
	Higher apprenticeship	100	50.0%	100.0% ▲	–
	All apprenticeships	500	44.0%	31.6% ▲	35.1% ▲
	Percentage level 3+	88.0%	–	*3.8%p* ▲	*12.3%p* ▲
All sector subject areas	**Intermediate apprenticeship**	**291,300**	**50.1%**	**-2.3%** ▼	**-11.5%** ▼
	Advanced apprenticeship	**190,900**	**55.3%**	**5.0%** ▲	**1.6%** ▲
	Higher apprenticeship	**27,200**	**63.7%**	**37.4%** ▲	**635.1%** ▲
	All apprenticeships	**509,400**	**52.8%**	**1.9%** ▲	**-2.2%** ▼
	Percentage level 3+	**42.8%**	**–**	***2.5%p*** ▲	***6.0%p*** ▲

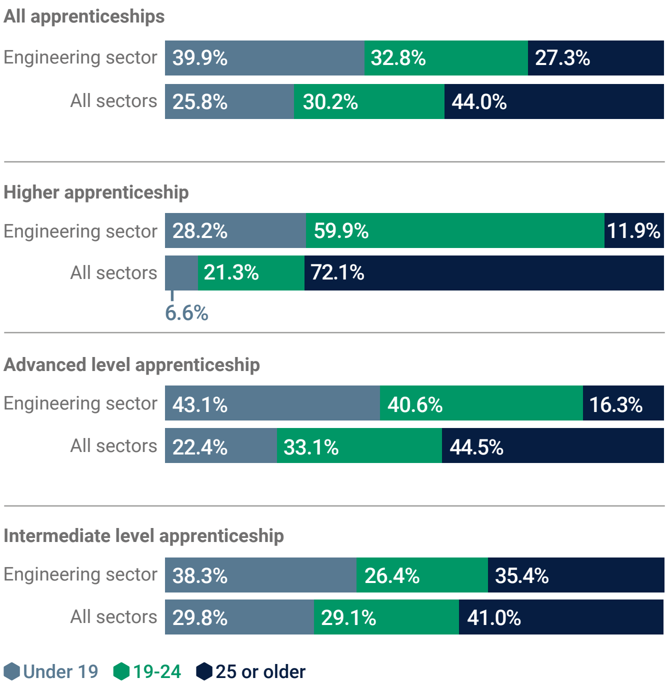
Source: Skills Funding Agency, 2010/2012, 2015/2016
To view this table with numbers from 2011 to 2012, see Figure 5.8 in our Excel resource.
'–' denotes that the percentage is either not available or is not applicable.

Age of apprenticeship starters

People starting engineering-related apprenticeships in the academic year starting in 2015 had a strikingly younger age profile than those starting apprenticeships as a whole (**Figure 5.9**). Across all sector subject areas, 44.0% of those starting apprenticeships in England were aged 25 or older, whereas for engineering-related apprenticeships, just 27.3% were 25 or older and 39.9% were under 19.

Looking within the engineering-related sectors by level, around two-fifths of starts at intermediate and advanced levels were by people under 19 (38.3% and 43.1% respectively). Those starting an engineering-related higher apprenticeship tended to be older, with only 28.2% being under 19.

Figure 5.9 Percentage of those starting apprenticeships in England by age, apprenticeship level and sector subject area in the academic year 2015 to 2016

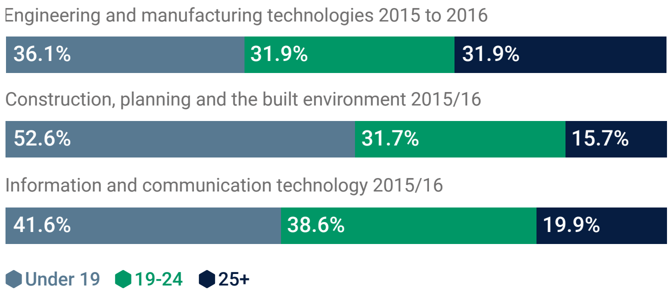


Source: Skills Funding Agency, 2015/2016

There were also some age variations by engineering sector subject areas (**Figure 5.10**). For example in 2015 to 2016, 52.6% of people starting apprenticeships in construction, planning and the built environment were under 19, compared with 36.1% of those in engineering and manufacturing technologies and 41.6% in ICT.

Those starting in construction, planning and the built environment tended to be younger than those starting in engineering and manufacturing or in ICT. There have been some variations over time. The age profile in 2015 to 2016 of those starting apprenticeships in both construction and ICT was slightly older compared with the previous year, while for engineering and manufacturing it became slightly younger.

Figure 5.10 Apprenticeship programme starts in England in key engineering-related sector subject areas by age in academic year 2015 to 2016



Source: Skills Funding Agency, 2015/2016
To view this chart with numbers from 2011 to 2012, see **Figure 5.10** in our Excel resource.

Apprenticeship achievements and gender

Engineering-related apprenticeships have grown in popularity in England. This is reflected in time series data on achievement (Figure 5.11 in our Excel resource), which shows that the number of people achieving success in this sector has grown faster than across all sectors combined. In the academic year starting in 2015, achievements in engineering-related areas increased by 9.3% compared with the previous year, which is more than double the increase in achievements across all sector subject areas (4.1%). Half of the annual growth in total in apprenticeship achievements in 2015 to 2016 (an increase of 10,800) came from engineering-related sector subject areas. Overall, nearly a quarter (23.5%) of all apprenticeship achievements in 2015 to 2016 were in an engineering-related sector (see Figure 5.11 and our Excel resource).

Engineering and manufacturing accounted for 70.0% of all engineering-related apprenticeship achievements, with the remaining 30.0% approximately equally divided between construction and ICT. That said, construction saw the most significant growth in terms of achievements in 2015 to 2016, at 12.3%. Though still substantial, growth in achievements was comparatively smaller in ICT (9.2%) and engineering and manufacturing technologies (8.8%).

In 2015 to 2016, 41.6% of engineering-related achievements were at advanced or higher apprenticeship level, which was slightly higher than observed across all sector subject areas (39.7%). This was largely driven by ICT, where 71.7% of achievements were within these higher levels. Conversely, in engineering and manufacturing and construction, planning and the built environment, the proportion of achievements at advanced or higher levels was below the overall average (38.6% and 24.8% respectively).

Overall, there has been little change in the proportion of engineering-related achievements at level 3+ over the last 4 years, even though there has been a 6.5 percentage point increase in the proportion of achievements at level 3+ across all sector subject areas. However, growth has not been static in each engineering-related area. Since 2011 to 2012, the proportion of level 3+ achievements in ICT has increased by one-fifth (21.4 percentage points), while it has fallen by 3.1 percentage points in engineering and manufacturing technologies and by 9.6 percentage points in construction, planning and the built environment.

Just 7.5% of people who completed an engineering-related apprenticeship in England were female, compared with 52.3% across all sector subject area achievements.

As with apprenticeship starts, women accounted for more than half of all sector subject apprenticeship achievements (52.3%) but only 7.5% of engineering-related apprenticeship achievements in 2015 to 2016. This proportion has barely changed from 2014 to 2015 (7.7%). ICT had the highest proportion of women among those achieving success in apprenticeships in 2015 to 2016, but this was still only one-sixth (15.9%). By comparison, women only accounted for 6.8% of achievements in engineering and manufacturing technologies and just 1.9% in construction, planning and the built environment.

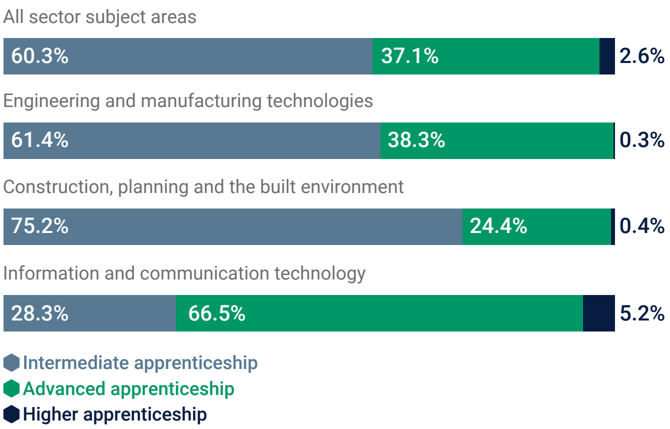
Figure 5.11 Apprenticeship achievements in engineering-related sector areas in England by level and gender in the academic year 2015 to 2016

		Total number of achievements	Percentage of sector subject area total	Percentage female
Construction, planning and the built environment	Intermediate	7,150	75.2%	1.3%
	Advanced	2,320	24.4%	3.8%
	Higher	40	0.4%	0.0%
	All	9,510	100.0%	1.9%
Engineering and manufacturing technologies	Intermediate	27,410	61.4%	8.5%
	Advanced	17,090	38.3%	4.0%
	Higher	150	0.3%	12.5%
	All	44,640	100.0%	6.8%
Information and communication technology	Intermediate	2,730	28.3%	24.1%
	Advanced	6,400	66.5%	12.5%
	Higher	500	5.2%	14.0%
	All	9,630	100.0%	15.9%
All engineering-related sector subject areas	**Intermediate**	**37,290**	**58.5%**	**8.3%**
	Advanced	**25,810**	**40.5%**	**6.1%**
	Higher	**690**	**1.1%**	**12.9%**
	All	**63,780**	**100.0%**	**7.5%**
Science and mathematics	Intermediate	30	13.6%	60.0%
	Advanced	180	81.8%	44.4%
	Higher	10	4.5%	0.0%
	All	220	100.0%	47.8%
All sector subject areas	**Intermediate**	**163,800**	**60.3%**	**50.2%**
	Advanced	**100,900**	**37.1%**	**54.7%**
	Higher	**7,000**	**2.6%**	**67.7%**
	All	**271,700**	**100.0%**	**52.3%**

Source: Skills Funding Agency, 2015/2016
To view this table with numbers from 2011 to 2012, see Figure 5.11 in our Excel resource.

Looking at achievements by level (Figure 5.12), apprenticeships in information and communication technology were more likely to be at advanced or higher level compared with all sector subject areas. However, the opposite was true for engineering and manufacturing technologies and construction, planning and the built environment.

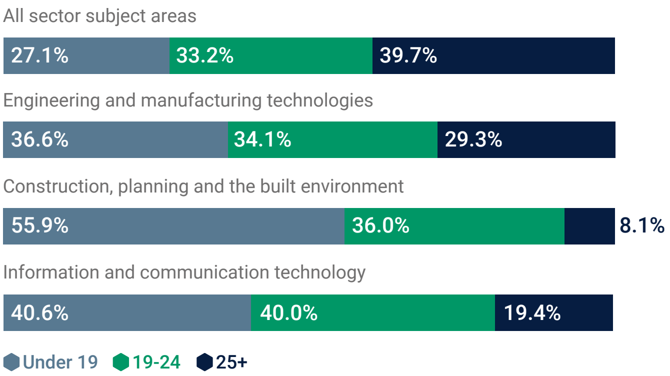
Figure 5.12 Apprenticeship achievements in England in engineering-related sector subject areas by level in the academic year 2015 to 2016



Source: Skills Funding Agency, 2015/2016
To view this chart with numbers from 2011 to 2012, see Figure 5.12 in our Excel resource.

Those achieving an engineering-related apprenticeship tended to be younger than the average across all sector subject areas, with higher proportions aged under 19 (Figure 5.13).

Figure 5.13 Apprenticeship achievements in England in engineering-related sector subject areas by age in the academic year 2015 to 2016



Source: Skills Funding Agency, 2015/2016
To view this chart with numbers from 2011 to 2012, see Figure 5.13 in our Excel resource.

The government's target is to increase the proportion of apprentices from a black and minority ethnic (BME) background by 20% by 2020.

Apprenticeship achievements by ethnicity

In 2015 to 2016, the proportion of people of BME ethnicity achieving an apprenticeship across all sector subject areas exceeded 1 in 10 for the first time (10.3%). This is in line with the government's target of increasing the proportion of apprentices from a black, Asian and minority ethnic (BME) background by 20% to 11.9% of starts by 2020.[5.48,5.49] However, engineering lagged behind, with only 6.7% of those achieving an apprenticeship in 2015 to 2016 identifying as BME (Figure 5.14). Within the sector this figure varied, from 15.0% in ICT to only 5.7% in engineering and manufacturing technologies and just 2.9% in construction, planning and the built environment. It was also apparent BME people were underrepresented at higher engineering-related apprenticeship levels. In fact, ICT was the only engineering-related subject in which any achievements were obtained by BME people. No BME individuals achieved higher level apprenticeships in construction, planning and the built environment or in engineering and manufacturing technologies.

By ethnicity, mixed/multiple ethnic groups and black/African/Caribbean/black British groups were particularly underrepresented among the apprenticeship achievements in construction, planning and the built environment, and in engineering and manufacturing technologies. Achievements for these groups in ICT were nearer the levels for all sector subject areas, though still lower. Very few people achieved apprenticeships in science and mathematics in 2015 to 2016 (just 210), but not a single one of them was of BME ethnicity.

Apprenticeships are a vital route to working in the engineering sectors. It is therefore a concern that ethnic diversity is even lower among those following this route than it is among those taking engineering subjects in higher education.

5.48 BIS. 'English Apprenticeships: Our 2020 Vision - Executive Summary', 2015.
5.49 FE Week. 'BAME target for apprenticeship diversity group', February 2017.

Figure 5.14 Apprenticeship achievements in England in engineering-related sector subject areas by ethnicity in the academic year 2015 to 2016

		Asian/Asian British	Black/African/Caribbean/black British	Mixed/multiple ethnic group	Other ethnic group	BME total	White	All with known ethnicity
Construction, planning and the built environment	Intermediate	0.7%	1.0%	1.3%	0.3%	3.2%	96.8%	7,120
	Advanced	0.9%	0.4%	0.9%	0.0%	2.2%	97.8%	2,320
	Higher	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	30
	All levels	0.7%	0.8%	1.2%	0.2%	3.0%	97.0%	9,470
Engineering and manufacturing technologies	Intermediate	3.3%	1.8%	1.7%	0.4%	7.3%	92.7%	27,170
	Advanced	1.5%	0.7%	1.0%	0.2%	3.5%	96.5%	16,950
	Higher	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	140
	All levels	2.6%	1.4%	1.4%	0.4%	5.8%	94.2%	44,260
Information and communication technology	Intermediate	4.4%	3.0%	1.5%	1.1%	10.0%	90.0%	2,710
	Advanced	7.6%	3.9%	3.0%	2.8%	17.3%	82.7%	6,350
	Higher	9.1%	0.0%	4.5%	0.0%	13.6%	86.4%	440
	All levels	6.7%	3.5%	2.6%	2.2%	15.1%	84.9%	9,500
All engineering-related sector subject areas	**Intermediate**	**2.9%**	**1.7%**	**1.6%**	**0.5%**	**6.7%**	**93.3%**	**37,000**
	Advanced	**3.0%**	**1.5%**	**1.5%**	**0.9%**	**6.8%**	**93.2%**	**25,620**
	Higher	**6.6%**	**0.0%**	**3.3%**	**0.0%**	**9.8%**	**90.2%**	**610**
	All levels	**3.0%**	**1.6%**	**1.6%**	**0.6%**	**6.8%**	**93.2%**	**63,230**
Science and mathematics	Intermediate	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0
	Advanced	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0
	Higher	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0
	All levels	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0
All sector subject areas	**Intermediate**	**5.0%**	**3.1%**	**2.0%**	**0.7%**	**10.7%**	**89.3%**	**161,850**
	Advanced	**3.6%**	**3.4%**	**2.0%**	**0.7%**	**9.7%**	**90.3%**	**99,680**
	Higher	**4.6%**	**4.3%**	**2.1%**	**0.3%**	**11.3%**	**88.7%**	**6,720**
	All levels	**4.5%**	**3.2%**	**2.0%**	**0.7%**	**10.4%**	**89.6%**	**268,250**

Source: FE data library, 2015/2016

Case study – Improving apprenticeship diversity

Isa Mutlib, Executive Director, BAME Apprenticeship Alliance

In 2015, the UK government apprenticeship taskforce launched a report setting a target of 3 million new apprenticeship starts for 2020. Within this report, the government set a further target to increase the uptake of apprenticeship from BAME (black, Asian and minority ethnic) communities by 20% by 2020. However, within many organisations there are barriers and stigmas which prevent the recruitment or development of people from the BAME community.

Though significant progress has been made with BAME diversity in the workplace, there are still a lot of challenges for organisations. The introduction of the apprenticeship levy has sparked organisations to think differently about how they develop new and existing staff, and created a focus on current skills shortages.

The BAME Apprenticeship Alliance brings together leaders within business and the apprenticeship sector to focus on promoting apprenticeship and skills among BAME communities through policy, advocacy and conversation. By working with organisations on diversity, we can build a platform to bring real action and change in the UK.

We structure ourselves around a community of organisations who serve as leaders in promoting the diversity of apprenticeships. Our community of organisations believe in the economic power of diversifying their workforces. It is with their influence, strategic alliance and thoughts that we are able to be a powerhouse for apprenticeship diversity policy, advocacy and conversations.

There is no better time than now to act upon bringing change to diversity policies, and with apprenticeships we can bring change right across the talent pipeline.

Apprenticeship success rates in England

Over the last 4 years for which data is available, apprenticeship success rates have declined across all sector subject areas in England, a trend which broadly holds true for engineering-related areas with a few exceptions (Figure 5.15). Compared with 4 years ago, success rates have risen at higher and advanced levels in ICT (by 14.7 and 0.9 percentage points). Over the last year, the rate increased at higher level in construction by 5.4 percentage points, but by less than 2 percentage points at intermediate level in engineering (1.6 percentage points) and at advanced level in ICT (1.1 percentage points).

However, the decline in success rates in England has been smaller among engineering-related apprenticeships than for apprenticeships overall. In the 4 years up to the academic year 2015 to 2016, apprenticeship success rates in all sector subject areas dropped by 7.7 percentage points, with just under half of the decline taking place in the last year. In the same period, the success rate for engineering and manufacturing technologies dropped by 5.4 percentage points. Falls in success rates were even lower for construction, planning and the built environment (4.3 percentage points) and information and communication technology (3.5 percentage points).

With the exception of construction, planning and the built environment at intermediate level and ICT at higher level, at every level success rates were higher among the three engineering-related subject areas than among apprenticeships overall. This difference was most marked among higher level apprenticeships in construction, planning and the built environment, where the success rate was 72.9% compared with just 58.3% across all subject areas at this level.

Over the last four years for which data is available, apprenticeship success rates have declined across all sector subject areas in England.

The decline in success rates has been smaller among engineering-related apprenticeships than for apprenticeships overall.

Figure 5.15 Apprenticeship success rates in England by level in the academic year starting 2015 to 2016, and changes over time

		Success rate (%)	Change over 1 year (%p)	Change over 4 years (%p)
Construction, planning and the built environment	Intermediate	64.2%	-2.6%p ▼	-2.4%p ▼
	Advanced	74.9%	-2.4%p ▼	-7.9%p ▼
	Higher	72.9%	5.4%p ▲	–
	All levels	66.6%	-2.6%p ▼	-4.3%p ▼
Engineering and manufacturing technologies	Intermediate	73.4%	1.6%p ▲	-6.1%p ▼
	Advanced	73.4%	-4.2%p ▼	-4.9%p ▼
	Higher	70.3%	-7.7%p ▼	-24.1%p ▼
	All levels	73.4%	1.1%p ▲	-5.4%p ▼
Information and communication technology	Intermediate	75.5%	-0.8%p ▼	-5.0%p ▼
	Advanced	77.6%	1.1%p ▲	0.9%p ▲
	Higher	58.2%	-11.4%p ▼	14.7%p ▲
	All levels	75.8%	0.2%p ▲	-3.5%p ▼
All sector subject areas	**Intermediate**	**66.5%**	**-4.7%p** ▼	**-8.7%p** ▼
	Advanced	**68.5%**	**-3.1%p** ▼	**-6.4%p** ▼
	Higher	**58.3%**	**-10.1%p** ▼	**-6.0%p** ▼
	All levels	**67.0%**	**-3.4%p** ▼	**-7.7%p** ▼

Source: Skills Funding Agency, 2011/2012, 2015/2016
To view this table with numbers from 2011 to 2012, see Figure 5.15 in our Excel resource.
'–' denotes no percentage available as figure for 2011/12 was 0.

5.5 – Apprenticeships in Scotland

The term 'modern apprenticeships' refers to all apprenticeships that are approved by the Modern Apprenticeships Group and thereby qualify for public sector funding. Additionally, there are technical apprenticeships and professional apprenticeships at higher levels (see Figure 5.2). While available, these have relatively low take up. There are also foundation apprenticeships (an alternative to upper secondary school higher qualifications), and graduate level apprenticeships have recently been introduced (which are similar to degree apprenticeships).

Figure 5.16 provides an indication of modern apprenticeship starts in Scotland in the academic year 2015 to 2016 by level, and how this has changed over the year before. As is the case in England, engineering-related apprenticeships are growing in popularity in Scotland. Between the academic year starting in 2014 and that starting in 2015, the number of starts in engineering-related apprenticeships rose by 6.8%, or nearly three times faster than apprenticeship starts in Scotland overall (which rose by 2.3%). Overall, engineering-related apprenticeships accounted for 33.1% of all apprenticeship framework starts in Scotland, which is higher than in England (22.8%).

The apprenticeship starts in Scotland tended to be at lower levels, with 77.6% of engineering-related starts at level 3 and a further 16.0% at level 2. Engineering-related apprenticeships were most commonly in construction: building (17.3% of all engineering-related starts), engineering (12.6%), automotive (13.6%) and IT and telecommunications (10.2%). The number of starts in IT and telecommunications increased significantly in 2015 to 2016 compared with the previous year (up 37.4%). In contrast, the number of engineering apprenticeship starts in 2015 to 2016 fell 21.3%.

Engineering-related apprenticeships are growing in popularity in Scotland. In the academic year starting 2015, the number rose by 6.8% relative to the year before, even as the overall number of apprenticeships declined in that same period.

Figure 5.17 illustrates the gender and age profile of starters in engineering-related modern apprenticeship frameworks in Scotland in the academic year starting in 2015. Overall the proportion of women starting such apprenticeships in 2015 to 2016 was very low at just 3.8% (compared to 40.7% for all apprenticeship frameworks). However, this varied widely by framework. For example, among those starting engineering apprenticeships, the proportion of women was slightly higher at 6.2%. The highest proportions of women starting engineering-related framework apprenticeships were in IT and telecommunications (15.3%), ICT professionals (8.9%) and oil and gas extraction (9.3%).

In terms of age profile (analysis of which can be found in our Excel resource), those starting on engineering-related apprenticeships were more likely than those on apprenticeships in general to be either 19 or younger, or 25 or older. In 2015 to 2016, 58.2% of engineering-related apprenticeship starters were 19 or younger, compared with 49.7% of all apprenticeship starters. A quarter (25.7%) of engineering-related apprenticeship starters were aged 25 or over compared with 20.6% of all apprenticeship starters.

Most achievements in engineering-related frameworks in Scotland were at level 3 in the academic year starting in 2015 (see Figure 5.18). The higher skilled nature of engineering is evident in these figures, as the proportion of engineering-related framework achievements increased with level. At level 2, 13.3% of achievements were in engineering-related frameworks; this increased to over a third (35.9%) at level 3, nearly two-thirds (65.2%) at level 4, and over three-quarters (79.2%) at level 5.

In terms of achievements by framework, there was much variation between the academic year 2015 to 2016 and the year before. Some variation is to be expected when comparing relatively small numbers, but there are still some notable increases and decreases. For example, achievements in automotive rose 1.6 times in 2015 to 2016 compared with the year before, while construction saw a fall in achievements by 14.0%. In the same period, achievements in IT and telecommunications more than doubled, and achievements in engineering rose by 8.8%.

Figure 5.16 Engineering-related modern apprenticeship starts in Scotland by level in the academic year 2015 to 2016, and change from previous year

Engineering-related frameworks	Level 2	Level 3	Level 4	Level 5	All levels	All levels – change over 1 year (%)
Automotive	71	1,094	0	0	1,165	4.2% ▲
Biotechnology	0	0	0	0	0	–
Bus and coach engineering and maintenance	0	38	0	0	38	31.0% ▲
Construction	0	23	0	0	23	-17.9% ▼
Construction: building	23	1,457	0	0	1,480	18.5% ▲
Construction: civil engineering	649	52	0	0	701	35.3% ▲
Construction (civil engineering and specialist sector)	0	0	0	0	0	-100.0% ▼
Construction (craft operations)	0	14	0	0	14	-33.3% ▼
Construction: professional apprenticeship	0	0	0	85	85	14.9% ▲
Construction: specialist	176	19	0	0	195	-4.4% ▼
Construction (technical operations)	0	0	0	0	0	–
Construction: technical	0	571	0	0	571	-5.1% ▼
Construction: technical apprenticeship	0	0	380	0	380	31.5% ▲
Electrical installation	0	714	0	0	714	16.1% ▲
Electronic security systems	0	64	0	0	64	8.5% ▲
Electrotechnical services	0	0	0	0	0	–
Engineering	0	1,073	0	0	1,073	-21.3% ▼
Engineering construction	0	38	0	0	38	-29.6% ▼
Extractive and mineral processing	231	27	0	0	258	116.8% ▲
Food manufacture	0	0	0	0	0	–
Gas industry	0	6	0	0	6	-79.3% ▼
Glass industry occupations	137	29	0	0	166	-16.2% ▼
Heating, ventilation, air conditioning and refrigeration	0	99	0	0	99	5.3% ▲
Information and communication technologies professionals	0	56	0	0	56	-33.3% ▼
IT and telecommunications	8	786	77	0	871	37.4% ▲
Land-based engineering	26	5	0	0	31	-8.8% ▼
Oil and gas extraction	0	43	0	0	43	-64.2% ▼
Plumbing	0	372	0	0	372	4.5% ▲
Polymer processing	0	0	0	0	0	–
Power distribution	41	0	0	0	41	0.0%
Printing	0	1	0	0	1	0.0%
Process manufacturing	0	44	0	0	44	-2.2% ▼
Rail transport engineering	0	0	0	0	0	–
Vehicle body and paint operations	0	0	0	0	0	–
Vehicle maintenance and repair	0	0	0	0	0	–
Water industry	8	0	0	0	8	-33.3% ▼
Wind turbine operations and maintenance	0	2	0	0	2	0.0%
All engineering-related framework starts	**1,370**	**6,627**	**457**	**85**	**8,539**	**6.8%** ▲
All framework starts	**9,055**	**15,803**	**862**	**98**	**25,818**	**2.3%** ▲
Percentage engineering-related framework starts	**15.1%**	**41.9%**	**53.0%**	**86.7%**	**33.1%**	

Source: Skills Development Scotland, 2014/2015, 2015/2016
To view this table with numbers from 2014/2015, see Figure 5.16 in our Excel resource.
'–' denotes no percentage available as figure for previous year was 0.

Figure 5.17 Women starting modern apprenticeships in engineering-related frameworks in Scotland in the academic year 2015 to 2016

Engineering-related frameworks	Total number of starts	Number of women starting	Percentage of all starts who were women
Automotive	1,165	31	2.7%
Biotechnology	0	0	–
Bus and coach engineering and maintenance	38	1	2.6%
Construction	23	0	0.0%
Construction: building	1,480	20	1.4%
Construction: civil engineering	701	3	0.4%
Construction (civil engineering and specialist sector)	0	0	–
Construction (craft operations)	14	0	0.0%
Construction: professional apprenticeship	85	1	1.2%
Construction: specialist	195	0	0.0%
Construction (technical operations)	0	0	–
Construction: technical	571	25	4.4%
Construction: technical apprenticeship	380	5	1.3%
Electrical installation	714	8	1.1%
Electronic security systems	64	0	0.0%
Electrotechnical services	0	0	–
Engineering	1,073	66	6.2%
Engineering construction	38	2	5.3%
Extractive and mineral processing	258	8	3.1%
Food manufacture	0	0	–
Gas industry	6	0	0.0%
Glass industry occupations	166	1	0.6%
Heating, ventilation, air conditioning and refrigeration	99	1	1.0%
Information and communication technologies professionals	56	5	8.9%
IT and telecommunications	871	133	15.3%
Land-based engineering	31	0	0.0%
Oil and gas extraction	43	4	9.3%
Plumbing	372	5	1.3%
Polymer processing	0	0	–
Power distribution	41	2	4.9%
Printing	1	0	0.0%
Process manufacturing	44	3	6.8%
Rail transport engineering	0	0	–
Vehicle body and paint operations	0	0	–
Vehicle maintenance and repair	0	0	–
Water industry	8	0	0.0%
Wind turbine operations and maintenance	2	0	0.0%
All engineering-related framework starts	**8,539**	**324**	**3.8%**
All framework starts	**25,818**	**10,505**	**40.7%**
Percentage engineering-related framework starts	**33.1%**	**3.1%**	

Source: Skills Development Scotland, 2014/2015, 2015/2016
To view this table with numbers from 2014 to 2015 and by age group, see Figure 5.17 in our Excel resource.
'–' denotes no percentage available as figure was 0.

Figure 5.18 Engineering-related modern apprenticeship achievements in Scotland by level in the academic year 2015 to 2016

Engineering-related frameworks	Level 2	Level 3	Level 4	Level 5	All levels	All levels – change over 1 year (%)
Automotive	52	465	0	0	517	55.7% ▲
Biotechnology	0	1	0	0	1	–
Bus and coach engineering and maintenance	0	3	0	0	3	0.0%
Construction	2	621	0	0	623	-14.0% ▼
Construction: building	4	75	0	0	79	507.7% ▲
Construction: civil engineering	393	9	0	0	402	24.5% ▲
Construction (civil engineering and specialist sector)	5	0	0	0	5	-96.8% ▼
Construction (craft operations)	0	133	0	0	133	84.7% ▲
Construction: professional apprenticeship	0	0	0	79	79	79.5% ▲
Construction: specialist	151	9	0	0	160	77.8% ▲
Construction (technical operations)	0	50	13	1	64	-66.1% ▼
Construction: technical	0	452	0	0	452	84.5% ▲
Construction: technical apprenticeship	0	0	331	0	331	67.2% ▲
Electrical installation	0	56	0	0	56	-40.4% ▼
Electronic security systems	0	1	0	0	1	–
Electrotechnical services	0	232	0	0	232	-34.3% ▼
Engineering	0	938	0	0	938	8.8% ▲
Engineering construction	0	70	0	0	70	-27.1% ▼
Extractive and mineral processing	119	25	0	0	144	-7.7% ▼
Food manufacture	2	1	0	0	3	-97.9% ▼
Gas industry	0	28	0	0	28	86.7% ▲
Glass industry occupations	120	30	0	0	150	-28.9% ▼
Heating, ventilation, air conditioning and refrigeration	0	60	0	0	60	3.4% ▲
Information and communication technologies professionals	0	117	0	0	117	17.0% ▲
IT and telecommunications	4	465	12	0	481	109.1% ▲
Land-based engineering	33	43	0	0	76	20.6% ▲
Oil and gas extraction	0	108	0	0	108	5.9% ▲
Plumbing	0	248	0	0	248	4.2% ▲
Polymer processing	0	2	0	0	2	–
Power distribution	10	0	0	0	10	–
Printing	1	0	0	0	1	-83.3% ▼
Process manufacturing	0	30	0	0	30	76.5% ▲
Rail transport engineering	0	0	0	0	0	-100.0% ▼
Vehicle body and paint operations	0	0	0	0	0	-100.0% ▼
Vehicle maintenance and repair	1	4	0	0	5	-97.0% ▼
Water industry	2	14	0	0	16	45.5% ▲
Wind turbine operations and maintenance	0	14	0	0	14	250.0% ▲
All engineering-related framework achievements	**899**	**4,304**	**356**	**80**	**5,639**	**5.6%** ▲
All framework achievements	**6,745**	**12,002**	**546**	**101**	**19,394**	**0.0%**
Percentage engineering-related framework achievements	**13.3%**	**35.9%**	**65.2%**	**79.2%**	**29.1%**	

Source: Skills Development Scotland, 2014/2015, 2015/2016
To view this table with numbers from 2014 to 2015, see Figure 5.18 in our Excel resource.
'–' denotes no percentage available as figure for previous year was 0.

Figure 5.19 Engineering-related modern apprenticeship achievements in Scotland by gender in the academic year 2015 to 2016

Engineering-related frameworks	Total number of achievements	Number of achievements by women	Percentage of all achievements by women
Automotive	517	6	1.2%
Biotechnology	1	0	0.0%
Bus and coach engineering and maintenance	3	0	0.0%
Construction	623	3	0.5%
Construction: building	79	3	3.8%
Construction: civil engineering	402	3	0.7%
Construction (civil engineering and specialist sector)	5	0	0.0%
Construction (craft operations)	133	3	2.3%
Construction: professional apprenticeship	79	1	1.3%
Construction: specialist	160	0	0.0%
Construction (technical operations)	64	10	15.6%
Construction: technical	452	16	3.5%
Construction: technical apprenticeship	331	8	2.4%
Electrical installation	56	0	0.0%
Electronic security systems	1	0	0.0%
Electrotechnical services	232	6	2.6%
Engineering	938	27	2.9%
Engineering construction	70	9	12.9%
Extractive and mineral processing	144	5	3.5%
Food manufacture	3	1	33.3%
Gas industry	28	1	3.6%
Glass industry occupations	150	0	0.0%
Heating, ventilation, air conditioning and refrigeration	60	0	0.0%
Information and communication technologies professionals	117	21	17.9%
IT and telecommunications	481	58	12.1%
Land-based engineering	76	0	0.0%
Oil and gas extraction	108	7	6.5%
Plumbing	248	2	0.8%
Polymer processing	2	0	0.0%
Power distribution	10	0	0.0%
Printing	1	0	0.0%
Process manufacturing	30	3	10.0%
Rail transport engineering	0	0	–
Vehicle body and paint operations	0	0	–
Vehicle maintenance and repair	5	0	0.0%
Water industry	16	0	0.0%
Wind turbine operations and maintenance	14	0	0.0%
All engineering-related framework achievements	**5,639**	**193**	**3.4%**
All framework achievements	**19,394**	**8,152**	**42.0%**
Percentage engineering-related framework achievements	**29.1%**	**2.4%**	

Source: Skills Development Scotland, 2014/2015, 2015/2016
To view this table with numbers from 2014 to 2015, see Figure 5.19 in our Excel resource.

In Scotland, just 3.8% of people starting engineering-related apprenticeships were women, compared to 40.7% across all apprenticeship frameworks.

Similar to the age profile for starts, those achieving engineering-related apprenticeships were less likely to be 20 to 24 years old (see **Figure 5.19a** in our Excel resource). In 2015 to 2016, 51.6% of those achieving an engineering-related apprenticeship were 19 or younger, compared with 50.1% of all apprenticeship achievements. At the other end of the scale 30.0% of those completing an engineering-related apprenticeship were aged 25 and older, in contrast to 20.9% of those in all frameworks.

Achievements across all age groups were, however, dominated by men (**Figure 5.19**). By any measure, the numbers of women completing apprenticeships in Scotland were very low. There were no apprenticeship frameworks in which women accounted for more than 50 of the total achievements. Looking at engineering-related apprenticeships generally, women accounted for just 2.4% of all completed apprenticeships in Scotland. This had changed little from 2014 to 2015 and was lower than in England.

Among the 16 to 19 year old age group, the highest number of achievements were in engineering (663) and construction (546). Within this age group there were also clusters of achievements across IT and telecommunications (252) and automotive (367) (see **Figure 5.19** in our Excel resource). Among 20 to 24 year olds, achievements were more evenly spread across the frameworks, with the highest single number in engineering (217). For those aged 25 and older, the highest number of achievements were in construction (technical) (417), followed by construction: technical apprenticeship (313).

These patterns are broadly similar to those seen the previous year (2014 to 2015), although for 16 to 19 year olds the number of achievements in IT and telecommunications more than doubled, by 2015 to 2016. In contrast, the figures for those achieving an apprenticeship in that age group in vehicle maintenance and repair decreased steeply from 148 to 5. There were slightly more achievements among the 20 to 24 year olds compared with 2014 to 2015, with engineering having the most achievements in both years (217 in 2015 to 2016 compared with 161 the year before). This change was also seen amongst those aged 25 and above, where achievements in construction: technical increased from 224 in the academic year starting in 2014 to 417 in 2015 to 2016.

Graduate level apprenticeships

Skills Development Scotland has been developing graduate level apprenticeships in parallel with the development of degree apprenticeships in England. In summer 2017, 4 courses were available for the first time:

- IT: software development (SCQF level 10)
- IT: management for business (SCQF level 10)
- civil engineering (SCQF level 8)
- engineering: design and manufacture (SCQF level 10)

Three of the four (at SCQF level 10) are equivalent to honours bachelor degrees and garner professional recognition (typically IEng), while the remaining one (civil engineering at SCQF level 8) is broadly equivalent to an HND or DipHE qualification.[5.50] We will look at achievements in graduate level apprenticeships in future reports.

5.6 – Apprenticeships in Wales

Wales has apprenticeships from foundation (level 2) to apprenticeship (level 3) to higher apprenticeships (level 4 to 8). Foundation apprenticeships are similar to intermediate apprenticeships in England. 'Apprenticeships' are on par to advanced apprenticeships in England and foundation apprenticeships in Scotland (see **Figure 5.2**).

Across all sector subject areas, including engineering-related ones, starts increased over the last year but have not reached the peaks seen between 2013 to 2014 and 2014 to 2015 (see **Figure 5.20**). Altogether, the number of engineering-related starts in 2015 to 2016 in Wales increased by 7.8% relative to the year previous, less than observed across all subject areas (21.5%). Nevertheless, this represents a larger annual increase in engineering-related starts than was seen in Scotland (6.8%) or England (7.4%) in the same period.

It is clear this varied greatly by framework. Starts in engineering and manufacturing technologies, for example, saw an annual increase of 14.8%, whereas there was only marginal rise in construction, planning and the built environment (2.4%).

The number of ICT apprenticeship starts in Wales actually decreased by 6.1% between the academic year beginning 2014 and the subsequent year.

In total in 2015 to 2016 there were 2,245 engineering and manufacturing technologies apprenticeship starts. Most were at level 3 (50.8%) and level 2 (45.9%), with just a few (3.3%) at level 4+. This marks a change from 2013 to 2014 when almost equal numbers started at levels 2 and 3.

Overall, there were fewer starts in engineering-related apprenticeships than in 2013 to 2014. Starts at higher apprenticeship level for all subjects have increased each year since 2012 to 2013, but just 2.2% of these were in engineering-related apprenticeships in 2015 to 2016.

5.50 Apprenticeships Scotland. 'Apprenticeships: Graduate Level Apprenticeships', 2017.

While starts across all subject areas have increased, achievements have decreased by 21.0% in the academic year starting in 2015 compared with the previous year (Figure 5.21). The decreases in ICT and engineering were slightly less, at -20.2% and -14.5% respectively. The number of achievements increased in construction by 1.9%. In engineering apprenticeship achievements, there has been a shift since 2012 to 2013 when more were at level 2 than 3, to equal proportions in 2015 to 2016.

Overall, the success rates (percentage of apprentices successfully completing their apprenticeships) range from around 80% to 90%. A higher proportion of people complete their apprenticeships at level 3 than 2 (numbers are too small at level 4+ to share). In general, achievement rates in engineering-related sector subject areas were higher in Wales than in England.

Those achieving engineering-related apprenticeships in Wales were usually young compared with those taking apprenticeships overall. Two in 5 (40.2%) were aged 19 or younger in the year 2015 to 2016, compared with 21.6% in all sector subject areas. This was similar to England.

5.7 – Apprenticeships in Northern Ireland

Figure 5.2 shows how the apprenticeship types and levels in Northern Ireland compare with the other home nations. As in Wales and England, Northern Ireland has higher level apprenticeships at level 4 and above. Its level 3 apprenticeships are similar to advanced apprenticeships in England and foundation apprenticeships in Scotland. Northern Ireland also has level 2 apprenticeships, which are similar to foundation apprenticeships in Wales and intermediate apprenticeships in England.

Figure 5.20 Programme starts in Wales by apprenticeship type and sector subject area in the academic year 2015 to 2016

	Foundation apprenticeships (level 2)	Apprenticeships (level 3)	Higher apprenticeship (level 4+)	All apprenticeships	All apprenticeships – change over 1 year (%)
Engineering and manufacturing technologies	1,030	1,140	75	2,245	14.8% ▲
Construction, planning and the built environment	1,170	970	20	2,160	2.4% ▲
Information and communication technology	40	80	35	155	-6.1% ▼
All engineering-related sector subject areas	**2,240**	**2,190**	**130**	**4,560**	**7.8%** ▲
All sector subject areas	**8,410**	**9,300**	**5,980**	**23,690**	**21.5%** ▲

Source: Statistics for Wales, 2015/2016
To view this table with numbers from 2012 to 2013, see Figure 5.20 in our Excel resource.
For comparative purposes, the data in this table has been aggregated by the sector subject groupings used in England.

Figure 5.21 Leavers in Wales attaining full framework, by apprenticeship type and sector subject area in the academic year 2015 to 2016

	Foundation apprenticeships (level 2)		Apprenticeships (level 3)		Higher apprenticeship (level 4+)	
	Leavers attaining full framework	Percentage	Leavers attaining full framework	Percentage	Leavers attaining full framework	Percentage
Engineering and manufacturing technologies	835	83%	845	89%	25	–
Construction, planning and the built environment	945	82%	675	85%	10	–
Information and communication technology	135	81%	215	86%	0	–
All engineering-related sector subject areas	**1,915**		**1,735**		**35**	
All sector subject areas	**6,395**	**82%**	**5,495**	**85%**	**2,170**	**72%**

Source: Statistics for Wales, 2015/2016
To view this table with numbers from 2012 to 2013, see Figure 5.21 in our Excel resource.
'–' indicates that percentages have denominators less than 50 and have been suppressed.

40.2% achieving engineering-related apprenticeships in Wales were 19 or younger.

In Northern Ireland, sector subject figures are only published for those on apprenticeships, rather than starts or completions. In October 2016, a higher proportion of engineering-related apprenticeships were at level 2/3 (28.1%) than for apprenticeships as a whole (18.0%) (see Figure 5.22). Just under one-quarter (1,024) of the 4,146 doing engineering-related apprenticeships were on engineering apprenticeships. The next 3 largest subject areas by participation were electrotechnical, vehicle maintenance and repair and plumbing.

As in the other home nations, a small minority of those on engineering apprenticeships in Northern Ireland were women (7.8%). This proportion is similar to that in England, but higher than in Scotland or Wales. As in Scotland, in Northern Ireland, the greatest number of female apprentices in a single framework were in food manufacture (200). There was just one female electrotechnical apprentice out of 708.

In Northern Ireland just one of the 708 electrotechnical apprentices was female.

Case study – An apprentice's perspective of being an engineer

Nathan Davies, 4th year apprentice, Highways Electrical Engineering, EON

I am in the fourth year of my level 3 highways electrician apprenticeship with EON, in highways lighting. I started on a traineeship after realising my previous job wasn't leading anywhere. The top two things I would like to gain from my apprenticeship are recognised qualifications, along with important life skills so that I can become the best I can, no matter what path I may take, also to take up every opportunity that may come my way and challenge myself. I have been working to become an authorised low voltage cable jointer. In November 2016, I won 'Contracting Apprentice of the Year' at the Highways Electrical Association awards.

By the end of my apprenticeship, I hope to move into further education in order to open more doors in terms of career progression. I want to look back on my apprenticeship and have no regrets, knowing that I have given 110% in everything.

I chose an apprenticeship within engineering as I want to provide solutions to problems, be a part of a team and help shape the future.

	All apprenticeships		
	Leavers attaining full framework	Percentage	All apprenticeships – change over 1 year (%)
	1,705	86%	-14.5% ▼
	1,630	83%	1.9% ▲
	355	84%	-20.2% ▼
	3,690		**-8.7%** ▼
	14,060	**81%**	**-21.0%** ▼

Figure 5.22 All participants on apprenticeships in Northern Ireland by framework in 2016

	Level 2		Level 2/3		Level 3 progression		All levels	
	Total no.	No. female	Total no.	No. female	Total no.	No. female	Total no.	% female
Construction	273	2	0	0	0	0	273	0.7%
Construction crafts	0	0	77	0	203	0	280	0.0%
Electrical and electronic servicing	5	0	0	0	0	0	5	0.0%
Electrical distribution and trans. engineering	0	0	39	5	15	3	54	14.8%
Electrical power engineering	6	0	0	0	0	0	6	0.0%
Electrotechnical	0	0	488	1	220	0	708	0.1%
Engineering	297	9	352	19	375	9	1,024	3.6%
Food manufacture	301	141	4	2	138	57	443	45.1%
Furniture production	5	0	0	0	1	0	6	0.0%
Gas utilisation, installation and maintenance	0	0	2	0	13	0	15	0.0%
Heating, ventilation, air conditioning and refrigeration	39	0	0	0	25	0	64	0.0%
IT and telecoms professional	113	44	0	0	47	10	160	33.8%
Land based service engineering	2	0	0	0	59	0	61	0.0%
Light vehicle body and paint operations	0	0	6	1	61	2	67	4.5%
Mechanical engineering services (plumbing)	94	1	62	0	159	0	315	0.3%
Print production	0	0	0	0	17	1	17	5.9%
Printing industry	24	2	0	0	0	0	24	8.3%
Vehicle body and paint	67	1	0	0	0	0	67	1.5%
Vehicle fitting	2	0	0	0	0	0	2	0.0%
Vehicle maintenance and repair	103	1	135	5	311	8	549	2.6%
Vehicle parts	5	0	0	0	1	0	6	0.0%
All engineering-related frameworks	**1,336**	**201**	**1,165**	**33**	**1,645**	**90**	**4,146**	**7.8%**
All frameworks	**2,946**	**1,057**	**1,402**	**200**	**3,441**	**1,311**	**7,801**	**32.9%**
Percentage engineering-related frameworks	**45.3%**	**19.0%**	**83.1%**	**16.5%**	**47.8%**	**6.9%**	**53.1%**	

Source: Northern Ireland Department for the Economy, 2016/2017

5.8 – Further education colleges

In September 2017, there were 37 fewer further education (FE) colleges in the UK than in the previous year (see Figure 5.23).

The economic sustainability of FE colleges in England was highlighted as an issue in the Post-16 Skills Plan. Between September 2015 and March 2017, 33 geographical area reviews of 323 FE colleges and sixth form colleges were undertaken. Higher education institutions, university technical colleges and local authorities could opt into the process but were not automatically included.[5.51] These reviews considered the long term sustainability and local skills needs, and gave recommendations to achieve these aims, including mergers between colleges. Yet the number of mergers was lower than expected and a number of proposed mergers have fallen through – some, ironically, because of failure to ensure government funding for long term sustainability. A number have also converted to academies.[5.52]

While there have been no reductions of colleges in Northern Ireland, Wales or Scotland, the reduction of 17 sixth form colleges and 20 general FE colleges in England has led to a cut of nearly 10% in the UK overall (Figure 5.23). The change is even greater when compared with 2013, when the UK had 402 FE colleges. England now has 53 fewer colleges, Scotland 10 fewer and Wales 5 fewer. While the number of colleges has reduced, this has often been through mergers, so it is difficult to say exactly what this means for the size of the FE sector overall.

Figure 5.23 Number of further education colleges in the UK by nation September 2016 and September 2017, and changes across time

	2016	2017	Change over 1 year (n)	Change over 4 years (n)
England	325	288	-37 ▼	-53 ▼
General further education colleges	209	189	-20 ▼	-30 ▼
Sixth form colleges	90	73	-17 ▼	-21 ▼
Land-based colleges	14	14	0	-1 ▼
Art, design and performing arts colleges	2	2	0	-1 ▼
Specialist designated colleges	10	10	0	0
Wales	14	14	0	-5 ▼
Scotland	26	26	0	-10 ▼
Northern Ireland	6	6	0	0
UK	**371**	**334**	**-37 ▼**	**-68 ▼**

Source: Association of Colleges, key further education statistics, 2013 to 2017
To view this table with numbers from 2013, see Figure 5.23 in our Excel resource

In addition to creating specialist national colleges, the government has allocated £170 million to establish institutes of technology.

There have also been policy developments affecting this aspect of further education. The creation of specialist national colleges was part of the response to the Sainsbury Review.[5.53] These are intended to focus on technical skills at levels 4 to 6 (equivalent to HNC to bachelor's degree level). The government announced nearly £80 million in May 2016 to create colleges in 5 areas.[5.54]

- high speed rail
- nuclear
- onshore oil and gas
- digital skills
- creative and cultural industries

The National Colleges for Digital Skills and for Creative and Cultural Industries opened in autumn 2016. The National Colleges for High Speed Rail (with hubs in Birmingham and Doncaster) and for Nuclear (hubs in Somerset and Cumbria) started their first courses in late 2017. The National College for Onshore Oil and Gas was intended to open at the same time but has been delayed.[5.55]

In addition to the national colleges, the government has indicated it will allocate £170 million to establish institutes of technology. First announced in 2015, these are intended to provide education and training provision at levels 3 to 5 (equivalent to A levels to bachelor's degree level) in 'technical disciplines'.[5.56,5.57] These institutes are to be based at existing providers and the government expect the first ones to open in 2018. Effectively, these will be a quality standard, and have been likened to the former centre of vocational excellence (CoVE) status launched by the Labour government in 2001.[5.58,5.59]

The national colleges and the institutes of technology are the latest of a number of vocationally related institute types and policy initiatives. Both are so new that it is too early to make any judgements as to their effects or their impact on the FE landscape and supply of skilled people to their respective industry sectors.

Vocational qualifications

In 2016, there were 3.7 million qualification certificates awarded for nationally accredited vocational qualifications across all sector subject areas in England, ranging from levels 2 to 7 (Figure 5.24). Of these, just under half a million (490,695) were in engineering-related subjects. The total number of qualifications awarded has steadily declined each year from 2012, when 5.1 million certificates were awarded, which is a

5.51 FE Week. 'College merger bites the dust for lack of government cash', August 2017.
5.52 FE Week. 'Further education & college area reviews in England 2015-17', August 2017.
5.53 HM Government. 'Post-16 Skills Plan', 2016.
5.54 UK Government. 'Government confirms £80 million for National Colleges to deliver the workforce of tomorrow', 2016.
5.55 FE Week. 'National College for Onshore Oil and Gas opening delayed', April 2017.
5.56 HM Government. 'Building our Industrial Strategy; green paper', January 2017.
5.57 HM Treasury. 'Fixing the Foundations: Creating a more prosperous nation', July 2015.
5.58 DfE. 'Institutes of Technology – Next Steps', 2017.
5.59 Offord P, Robertson A. 'Institutes of technology £170m going to existing providers'. FE Week, 2017.

drop of over one-quarter (-27.4%). The number of engineering-related certificates awarded has declined too, but by less (-15.2%). This is mainly because engineering has seen a lower decline in certifications at level 2 and had fewer qualifications proportionally at level 2 to begin with.

Across England, Wales and Northern Ireland, most of the engineering-related vocational qualifications awarded were in engineering and manufacturing technologies.

As mentioned in previous reports, for both engineering and across all subjects, there has been a decline in overall numbers as well as a growing trend toward higher levels. As fewer people take qualifications at level 2, relatively more have taken them at levels 3 and above.

Qualifications awarded in Scotland and Northern Ireland have also moved away from level 2 to higher levels. In England, Wales and Northern Ireland the bulk of certificates awarded in 2016 remained at level 2 in engineering and manufacturing technologies, and in construction, planning and the built environment. However, over the last 4 years, the number of certificates has generally declined across all the engineering sector subject areas. In Wales, the volume of level 2 certificates awarded decreased between 2012 and 2016 by -18.0% (compared with a drop of -8.0% for all sector subject areas). In Northern Ireland, there has been some growth at level 2, with the numbers of certifications increasing over 4 years by 6.9%. However, this increase includes a drop of -6.9% between 2015 and 2016. At level 3, the number of certificates awarded increased by 4.4% over 4 years in Wales and by 48.6% in Northern Ireland.

In 2016, there were 415,070 qualifications awarded in Wales, of which 33,200 were engineering-related. In Northern Ireland, 119,115 were awarded in total, including 17,035 engineering-related ones.

Across England, Wales and Northern Ireland, most of the engineering-related qualifications awarded were in engineering and manufacturing technologies. In 2016, England had the most engineering-related certificates awarded (490,695) but also the greatest percentage decrease compared with 2012 (a fall of 15.2%). Between 2016 and 2015, both England and Wales saw decreases of over 5%. In contrast, numbers increased by nearly one-quarter (24.7%) in Northern Ireland. At level 4+, there were big increases in England and Wales between 2012 and 2016, of 76.51% and 156.5% respectively. However, absolute numbers remain relatively small: in England there were 15,440 certificates awarded and in Wales just 295. In Northern Ireland, the numbers of certificates at level 2 increased between 2012 and 2016 by 6.9% and at level 3 they increased by 48.6% over the same period. This more than offset the decrease by 19.4% at level 4+, to give an overall increase of 18.5% to 17,035 certificates awarded at all levels.

Figure 5.24 Certificates awarded in England, Wales and Northern Ireland in all vocational qualifications for key STEM and engineering-related subject areas (2016)

		England	
		No.	Change over 1 year (%)
Engineering and manufacturing technologies			
Engineering	Level 2	67,830	-3.5% ▼
	Level 3	39,045	-2.9% ▼
	Level 4 to 7	4,940	13.3% ▲
	All levels	111,815	-2.6% ▼
Manufacturing technologies	Level 2	84,590	-16.3% ▼
	Level 3	12,710	4.0% ▲
	Level 4 to 7	1,180	38.8% ▲
	All levels	98,480	-13.7% ▼
Transportation operations and maintenance	Level 2	44,180	-14.3% ▼
	Level 3	21,960	4.4% ▲
	Level 4 to 7	360	9.1% ▲
	All levels	66,500	-8.8% ▼
Construction, planning and the built environment			
Building and construction	Level 2	91,505	-0.1% ▼
	Level 3	51,890	1.4% ▲
	Level 4 to 7	6,520	19.0% ▲
	All levels	149,915	1.1% ▲
Information and communication technology			
ICT practitioners	Level 2	8,460	-37.1% ▼
	Level 3	53,085	0.3% ▲
	Level 4 to 7	2,440	-0.2% ▼
	All levels	63,985	-7.0% ▼
Science and mathematics			
Science	Level 2	1,600	-24.5% ▼
	Level 3	25,410	4.9% ▲
	Level 4 to 7	485	67.2% ▲
	All levels	485	67.2% ▲
Mathematics and statistics	Level 2	44,110	5.5% ▲
	Level 3	24,650	0.3% ▲
	Level 4 to 7		–
	All levels	68,760	3.6% ▲
All engineering-related sector subject areas			
	Level 2	**296,565**	**-9.6%** ▼
	Level 3	**178,690**	**0.7%** ▲
	Level 4 to 7	**15,440**	**14.7%** ▲
	All levels	**490,695**	**-5.4%** ▼
All vocational qualifications for all sector subject areas			
	Level 2	**2,366,245**	**-10.5%** ▼
	Level 3	**1,225,080**	**0.9%** ▲
	Level 4 to 7	**128,715**	**4.6%** ▲
	All levels	**3,720,040**	**-6.5%** ▼

Source: Ofqual, 2012 to 2016
To view this table with numbers from 2012, see Figure 5.24 in our Excel resource.
'–' denotes values of percentages are not available. Mathematics and statistics vocational

	Wales			Northern Ireland		
Change over 4 years (%)	No.	Change over 1 year (%)	Change over 4 years (%)	No.	Change over 1 year (%)	Change over 4 years (%)
-25.6% ▼	5,915	-16.9% ▼	-28.0% ▼	1,735	-10.8% ▼	-6.7% ▼
-13.3% ▼	2,770	-1.6% ▼	-26.6% ▼	1,605	9.2% ▲	16.7% ▲
70.9% ▲	110	-15.4% ▼	83.3% ▲	170	-32.0% ▼	-8.1% ▼
-19.6% ▼	8,795	-12.6% ▼	-27.0% ▼	3,510	-4.2% ▼	2.6% ▲
-13.9% ▼	7,010	-11.5% ▼	-12.1% ▼	4,875	9.4% ▲	60.9% ▲
17.5% ▲	490	-17.6% ▼	6.5% ▲	465	8.1% ▲	78.8% ▲
1.7% ▲	15	200.0% ▲	-25.0% ▼	50	-16.7% ▼	-56.5% ▼
-10.6% ▼	7,515	-11.8% ▼	-11.1% ▼	5,390	9.0% ▲	58.3% ▲
-30.7% ▼	3,100	12.3% ▲	44.9% ▲	745	-3.9% ▼	-6.3% ▼
19.7% ▲	765	-2.5% ▼	19.5% ▲	650	4.0% ▲	6.6% ▲
554.5% ▲	0	–	–	50	-41.2% ▼	-23.1% ▼
-19.1% ▼	3,865	9.0% ▲	39.0% ▲	1,445	-2.7% ▼	-1.7% ▼
-15.0% ▼	6,590	-6.7% ▼	-23.1% ▼	1,945	-16.7% ▼	-20.9% ▼
1.3% ▲	3,320	-1.0% ▼	-3.1% ▼	2,115	2.9% ▲	46.4% ▲
79.4% ▲	160	357.1% ▲	357.1% ▲	135	3.8% ▲	-22.9% ▼
-7.8% ▼	20,175	-8.8% ▼	-13.4% ▼	4,195	-7.2% ▼	2.8% ▲
-82.6% ▼	780	-52.1% ▼	-52.1% ▼	660	-44.3% ▼	-43.8% ▼
51.8% ▲	2,165	3.8% ▲	167.3% ▲	1,720	14.3% ▲	138.9% ▲
141.6% ▲	10	100.0% ▲	–	115	-47.7% ▼	9.5% ▲
-24.4% ▼	2,955	-20.6% ▼	21.1% ▲	2,495	-14.3% ▼	24.8% ▲
-98.9% ▼	6,450	-47.2% ▼	31.9% ▲	600	-43.7% ▼	-26.4% ▼
101.8% ▲	1,340	9.8% ▲	208.0% ▲	580	31.8% ▲	222.2% ▲
304.2% ▲	0	–	–	35	-30.0% ▼	-30.0% ▼
304.2% ▲	7,790	-42.0% ▼	46.3% ▲	1,215	-21.9% ▼	16.3% ▲
448.3% ▲	2,690	6.5% ▲	144.5% ▲	50	66.7% ▲	–
3.0% ▲	90	100.0% ▲	157.1% ▲	0	–	–
–		–	–		–	–
115.0% ▲	2,780	8.2%	144.9% ▲	50	66.7% ▲	–
-27.6% ▼	**23,395**	**-11.7% ▼**	**-18.0% ▼**	**9,960**	**-6.9% ▼**	**6.9% ▲**
11.4% ▲	**9,510**	**-1.3% ▼**	**4.4% ▲**	**6,555**	**7.7% ▲**	**48.6% ▲**
76.5% ▲	**295**	**68.6% ▲**	**156.5% ▲**	**520**	**-30.2% ▼**	**-19.4% ▼**
-15.2% ▼	**33,200**	**-8.6% ▼**	**-12.1% ▼**	**17,035**	**-2.8% ▼**	**18.5% ▲**
-40.5% ▼	**266,530**	**-14.1% ▼**	**-8.0% ▼**	**84,035**	**-13.7% ▼**	**-11.0% ▼**
19.5% ▲	**142,360**	**-1.9% ▼**	**39.3% ▲**	**30,760**	**1.9% ▲**	**14.3% ▲**
8.3% ▲	**6,180**	**18.6% ▲**	**57.3% ▲**	**4,320**	**-12.7% ▼**	**24.0% ▲**
-27.4% ▼	**415,070**	**-9.9% ▼**	**4.9% ▲**	**119,115**	**-10.1% ▼**	**-4.5% ▼**

qualifications are not available at levels 4-7. In Northern Ireland no qualifications were taken at this level 4 years ago.

What apprenticeships need to do to go from good, to great

31% of business leaders said they intend to use the levy to boost the number of apprentices they recruit

47% agreed that the levy was a great way to get employers to invest in training

34% believed the levy would help to raise apprenticeship quality but only a third (35%) of respondents believed that apprentices could fill roles for skilled trades

City & Guilds Group

Caroline Roberts,
Head of Policy,
City and Guilds

Who we are

Founded in 1878, City & Guilds is synonymous with apprenticeships. We have been at the forefront of shaping and reshaping them over the years, including the most recent review of the system where we were on two-thirds of the trailblazers, working closely with employers.

Changing skills landscape

The last year has seen significant reform in the skills sector, the introduction of the apprenticeship levy and further consultation from the DfE expected by the end of 2017. This has all been carried out with the intention to create parity for the technical education system with academic routes.

The apprenticeship levy provides a good opportunity for companies in the engineering sector to meet their skills needs with home-grown talent, even more crucial since the decision to leave the EU. The intended benefits of the levy, will only be realised however if businesses make the most of it. To ensure this takes place, a collaborative effort by the government and education sector is needed to ensure employers are fully informed on the roles which could be filled by apprentices.

Most business leaders are not aware of the full scope of business needs and skills gaps that apprenticeships can address.

According to findings in *Skills Shortage Nation* which we published earlier this year, 31% of business leaders said they intend to use the levy to boost the number of apprentices they recruit, and 47% agreed that the levy was a great way to get employers to invest in training. A further 34% believed the levy would help to raise apprenticeship quality, but only a third (35%) of respondents believe that apprentices could fill roles for skilled trades – traditionally an area where skills are developed through apprenticeships.

However, while the majority know about the new apprenticeship system, most are not aware of the full scope of business needs and skills gaps that apprenticeships can address. We would therefore urge the government to do its utmost to communicate with businesses.

Drive for quality on apprenticeship numbers needed

The target of creating 3 million apprenticeships has helped raise the profile of apprenticeships and has forced the government to take action to ensure the target is met. The government do, however, need to ensure that they keep quality at the heart of any reforms and ensure that the new apprenticeships are seeking to close skills gaps in the economy.

There remains a real shortage of apprenticship provision at levels 4 and 5.

If the new apprenticeship levy does not result in the creation of quality apprenticeships by employers then the government runs the risk of missing the 3 million target and the UK industry's future skills needs not being met. To combat this, the government must recognise the challenges that businesses are likely to face and help to overcome them.

We do however face a challenge as there remains a real shortage of provision at levels 4 and 5, an area identified as one of largest skills gaps by UKCES and the Engineering Council in their employer surveys. This is significant, as progression of learners from apprenticeship programmes at level 3 is important both economically and in terms of social mobility. In this regard, we welcome the recent announcement by the DfE confirming its intention to conduct a review into level 4 and 5 education provision, and it focus on how technical qualifications at this level can better address the needs of learners and employers.

Better skills utilisation to encourage economic growth

We welcomed the government's Industrial Strategy green paper and its focus on skills as a key driver for improved productivity, most notably its focus on technical and basic skills and its drive to empower skills decisions on a regional level. We would however have liked to see a greater emphasis on making skills an integrated part of the strategy and hope to see more of this in the upcoming strategy from the government. The green paper emphasised the importance of raising skills levels and bolstering those of the future workforce, however, it is important that employers maximise the skills of their own employees, to ensure sustainable economic growth in the UK. Ensuring employers make full use of the skills base available to them, and ensuring their employees are equipped for the future world of work will help maximise productivity and ensure the UK has the ability to compete on an international scale.

Clear and comprehensive careers advice

In order to ensure that those entering employment or changing jobs have the correct skills, more and better careers advice is needed. City & Guilds has previously highlighted the need for, and have commented that it should be as easy for young people to opt for, and access an apprenticeship as it is for them to access higher education. This is currently held back through a lack of comprehensive careers advice, and that where it does exist, it is skewed away from the intended employment destination at the end of full-time education (at all levels) and towards a course-based approach. The careers strategy is long-overdue and our hope is that it is published in co-ordination with the Industrial Strategy to ensure cross-departmental and regional considerations are included in the proposals.

Careers advice, however, should not just be for young people, and is also needed for older workers looking to change careers. Such advice and planning will become increasingly important in light of Brexit negotiations and the impact which they could potentially have on inward migration. The engineering and construction sectors in particular will need to ensure that they have the skills and workforce in place to prepare for some of the large-scale infrastructure projects currently in the UK pipeline.

Unless effective careers provision and guidance is provided, the UK's ambitions on productivity will struggle.

Challenges and opportunities

Although the skills landscape is going through a period of significant change, there is much to be welcomed amongst the challenges. If the levy is used to its full potential by employers with effective guidance from the government, then this will go some way in helping to reach the 3 million target whilst not compromising quality.

Challenges do however remain in ensuring that the skills base at all levels and ages is used to its full potential. Unless effective careers provision and guidance is provided to help people get into a job, help them in their roles, and then onto their next jobs then the UK's ambitions on productivity will struggle.

Finally, the proposals for devolution of power away from Westminster and into the UK's regions should be welcomed. A coordinated effort from local employers, education providers and local government working together through a more holistic approach, will help learners and local areas flourish as the UK looks to leave the EU.

6 - Higher education

69% of engineering and technology postgraduate taught entrants were from overseas

16% of engineering and technology first degree entrants were women

Key points

The policy landscape

There are widespread concerns that the UK's decision to leave the EU will make the higher education (HE) sector less attractive to international staff and students, and make it harder to access research funding and collaboration opportunities. Together, these could negatively affect the quality of UK HE teaching and research, particularly in engineering, which has a high proportion of students from overseas. Ultimately, this could damage the engineering pipeline.

Significant policy changes over recent years have added to the uncertainty, including reductions in public funding across the UK and increasing undergraduate tuition fees in England. The new Higher Education and Research Act, introduced during 2017, will deepen the existing market-led approach.

Trends in total student numbers

Total student numbers have decreased over the last 5 years for which data is available, with the biggest fall in the year when tuition fee arrangements changed. However, in the academic year 2015 to 2016, there was a small year-on-year increase in HE student enrolments for the first time since 2010 to 2011.

In recent years, the number of students taking first degrees has continued to grow, but the number taking 'other' undergraduate courses has gone down significantly. This is likely associated with an overall decline observed in in part-time studying, which has decreased by 30% between the academic years starting in 2011 and 2015.

There was a 1% increase in the number of HE students studying engineering and technology in 2015 to 2016 compared with the previous year, taking the total to 163,255. This was due largely to a rise in entrants at first degree level. It is the third consecutive year in which numbers have increased, whereas overall HE student numbers have fallen in 2 of those years.

Domicile

There are many international students studying engineering and technology in the UK, particularly at taught and research postgraduate levels (68.9% and 61.1% of entrants respectively). This reflects the discipline's great success in attracting international students, but means that the continuation of these courses – and the supply of engineering and technology skills at level 4+ – may be affected by changes to the mobility of international students.

Gender

In 2015 to 2016, women comprised just 16.0% of first degree entrants in engineering and technology entrants, compared with 50.1% of STEM and 56.1% of first degree entrants overall. This makes it the subject with the second lowest proportion of female first degree entrants.

Women were better represented at postgraduate level, making up a quarter of both taught and research students. This suggests they are more likely to pursue postgraduate study than their male peers. Nevertheless, the fact remains that women are severely underrepresented in engineering and technology across all levels of HE, including at postgraduate levels.

Given that women are increasingly dominant in HE overall and perform highly academically, they must remain a priority target group for the engineering sector.

Ethnicity

Engineering and technology was more ethnically diverse than most other subject areas. Students from a BME background accounted for 31.4% of UK domiciled first degree entrants, 29.0% of taught postgraduate entrants and 24.1% of postgraduate research entrants.

However, degree attainment outcomes for BME first degree engineering and technology qualifiers are consistently lower on average than white qualifiers. Much research has been done on the degree attainment gap between ethnic minorities and white students, which has been shown to persist even accounting for a host of variables expected to impact on attainment. These findings suggest that systemic causes must be addressed if all talent is to be harnessed effectively.

About the data

Analysis in this chapter is based on data taken from the Higher Education Statistics Agency (HESA) student record from the academic years ending in 2004 to 2016. All data has been weighted by full-person equivalent (FPE) and counts rounded to the nearest 5 in accordance with HESA policy. Percentages are based on those students for whom the data is known. In the data tables, '–' represents a percentage that would otherwise be calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.

Engineering and technology is one out of 19 subject areas within **the Joint Academic Coding System (JACS)** used by HESA to classify academic subjects. This is the highest level by which subjects can be analysed; they can be further disaggregated by discipline, each of which has a 2-digit code. The engineering and technology subject area comprises the disciplines H0-J9. To highlight possible differences within engineering and technology and assist those who may have a specific interest in a particular discipline, some tables in this chapter present engineering and technology data at this 2-digit level.

To achieve consistency across HE sector statistics, the analysis in this chapter has been aligned with the standard HESA degree level classifications. As a result, some data may not be directly comparable with figures presented in previous reports.

6.1 – Participation in UK higher education

The policy landscape

Leaving the European Union

In its report *Exiting the EU: challenges and opportunities for higher education*, the House of Commons Education Committee recognised that the consequences for higher education (HE) of the UK exiting the EU were uncertain. It recommended clear direction from the government to maximise the HE sector's contribution to a successful post-exit UK.[6.1] These sentiments appear to be overwhelmingly shared by the HE sector.

A key concern is whether the UK leaving the EU will affect the HE sector's ability to attract international students. In recent years, the number of international students has already gone down due to tightening of their entitlement to post-study work opportunities and changes to requirements for non EU students applying for post-study work visas.[6.2] Yet international students are of great importance, both to the UK HE sector and to the country more widely.

A recent report by Oxford Economics for Universities UK found that tuition fees from international students accounted for over 14% of total university income.[6.3] It further estimated that spending by international students generated £25.8 billion in gross output for the UK's economy in 2014 to 15 and 206,600 full time equivalent jobs nationally. A decline in international students may, therefore, not only affect universities' ability to plan strategically, but also leave the sector financially vulnerable. It is also likely to reduce the diversity of the academic environment, the experience of UK students and the UK's global 'soft power'.

Any change to the free movement of people in the EU would, in principle, only directly affect potential students from the EU, who in 2015 to 16 comprised a quarter of international entrants to UK HE (25.6%). However, the UK's decision to leave the EU may also have an impact on other potential students' perceptions of the UK as an attractive place to study. The QS Intelligence Unit surveyed students from 10 countries who were looking to study abroad and uncovered a common concern they would now be unwelcome.[6.4] According to this research, many respondents "vocalised a view that the UK had gone from appearing like an open, inclusive country … to one that is less progressive." It continued, "[This] seemed to have a knock-on effect on students' overall conception of the UK, including the reputation of British universities… as a less prestigious and desirable place to study." Even if these are perceptions rather than the reality, this is likely to reduce applications and, therefore, income. It is also possible that the current restrictions on non EU students could apply to a greater proportion of international students in UK HE in the future.

The engineering pipeline is particularly vulnerable to changes that may result from the UK leaving the EU, due to the high proportion of HE engineering and technology students who are from overseas. At taught postgraduate level, for example, 68.9% of engineering and technology entrants in 2015 to 16 were non UK domiciled, and within some disciplines this exceeded 80%. A number of universities have highlighted the importance of international students to ensuring courses remain financially sustainable, particularly in higher-cost disciplines. [6.5] Many engineering courses are reliant on international students, so these courses may not be viable without them. This, in turn, will affect access to such programmes for UK students, impacting the engineering skills supply on two fronts.

Leaving the EU could also affect the quality of UK HE teaching and research, potentially reducing the outward mobility opportunities for academic staff, the ability to attract international talent and the UK's access to research and innovation funding and collaboration. In a survey of academics conducted by YouGov on behalf of the University and College Union (UCU), 42% indicated they were more likely to consider leaving UK higher education as a result of the EU referendum result – a view expressed by three-quarters (76%) of non UK EU academics.[6.6] 29% of respondents said they already knew of academics leaving the UK and over two-fifths (44%) said they knew of academics who had lost access to research funding as a direct result of the vote. An overwhelming majority (90%) expressed concern that the UK leaving the EU would have a negative impact on the UK HE sector.

6.1 House of Commons Education Committee. 'Exiting the EU: challenges and opportunities for higher education'. Ninth Report of Session 2016–17, April 2017.
6.2 HEPI, Kaplan International Pathways and London Economics. 'The determinants of international demand for UK higher education'. HEPI report 91, January 2017.
6.3 UUK. 'The economic impact of international students', March 2017.
6.4 QS Intelligence Unit. 'Is Brexit Turning International Students Away From the UK?' 2017, p10.
6.5 Russell Group. 'Russell Group response to House of Commons Education Committee inquiry: The impact of exiting the EU on Higher Education', November 2016.
6.6 UCU. YouGov Brexit HE bill survey, 2017.

Higher Education and Research Act 2017

Significant changes to the HE policy landscape are also causing concern. There has been considerable change in recent years, with reductions in public funding across the UK and increasing undergraduate tuition fees in England. 2017 furthermore saw the passage of the Higher Education and Research Act, deepening the market approach already in place. Described as "the most important legislation for the sector in 25 years,"[6.7] the aims of the Higher Education and Research Act were to create more competition and choice, boost productivity in the economy, ensure students receive value for money and strengthen the UK's research and innovation sector.[6.8]

To achieve this, the Act made way for a new regulator and funding council for universities called the Office for Students (OFS), which will hold the statutory responsibility for standards and quality. Incorporating the functions of the Office for Fair Access (OFFA), OFS will require universities to publish material on the fairness of their admissions, as well as information "helpful to international students." Notably, OFS will also oversee the Teaching Excellence Framework (TEF), an assessment of teaching quality that was trialled in 2016: this is described in more detail in **Chapter 8**. The government has previously announced an intention for TEF ratings to influence the degree to which universities are able to increase tuition fees in line with inflation. However, whether this occurs will depend on the outcome of an independent review of the TEF in 2019 and subsequent government decisions. It may also be influenced by the outcomes of the review of student finance in England announced by the Prime Minister in October 2017. Such a proposal has been met with concern, with 76% of academics surveyed by UCU, for example, believing that linking the TEF to tuition fees would have a negative impact on higher education.[6.9] From academic year 2019 to 2020, participation in TEF will also become an ongoing registration condition for approved HE providers with more than 500 undergraduate students.

The Act also brought the 7 research councils, Innovate UK and the research functions of the Higher Education Funding Council for England (HEFCE) under a single body called UK Research and Innovation (UKRI). Additionally, it introduced a new body, Research England, which will take on HEFCE'S research functions, including responsibility for quality-related (QR) research funding, and made provisions for universities to charge higher annual fees for 'accelerated degrees' that are taught over a shorter period of time.

The Act and the impending departure of the UK from the EU signal major changes for the HE sector. In the context of these far-reaching changes, this chapter focuses on participation in undergraduate and postgraduate programmes and how trends differ for UK and international students, as well as by mode, gender and ethnicity.

Higher Education and Research Act 2017: key facts

The Higher Education and Research Act included the following:

- **Creation of Office for Students (OfS)**, a new regulator and funding council that will hold the statutory responsibility for quality and standards, and the awarding of university title and degree awarding powers. The OfS will also have powers in relation to monitoring universities' fairness in admissions and their financial sustainability.
- **Introduction of the Teaching Excellence Framework (TEF)**, an assessment exercise into the quality of teaching in universities that will rate universities as Gold, Silver or Bronze. Before announcing a one-year freeze for academic year 2018 to 2019, the government was expected to allow tuition fees to increase by the rate of inflation for universities participating in TEF and meeting minimum eligibility requirements until 2020. After 2020, this can be linked to results in the TEF.
- **Changes to fees and student finance**, including allowing the Student Finance Company to make alternative methods of financing available for those unable to take out student loans, and universities being allowed to charge higher annual fees for accelerated degrees.
- **Creation of UK Research and Innovation (UKRI)**, a single strategic research body under which the 7 research councils, Innovate UK and the research functions of HEFCE will sit. While the research councils will maintain their existing composition within UKRI, they will be subject to a single accounting officer and have responsibility for interdisciplinary collaboration. A new body, Research England, will take on HEFCE'S research functions, including allocating quality-related (QR) research funding.

Trends in overall student numbers

Overall student numbers have gone down over the last 5 years for which data is available, with the most prominent fall occurring in the academic year 2012 to 2013, which coincided with changes to tuition fee arrangements. The year 2015 to 2016 is therefore notable in that, for the first time since 2010 to 2011, there was a year on year increase in HE student enrolments. Over 2.28 million students enrolled at 164 universities: up 1.0% compared with the previous year.

There was also a 1.0% year on year increase in students studying engineering and technology in 2015 to 2016, taking the number to 163,255 (**Figure 6.1**). This is the third consecutive year that the number of engineering and technology students has risen, two of which were in opposition to the trend in total student numbers.

6.7 Wonkhe. 'Be it enacted: The Higher Education and Research Act', 2016.
6.8 DfE. 'Higher Education and Research Bill', May 2016.
6.9 Wonkhe. 'Be it enacted: The Higher Education and Research Act', 2016.

Figure 6.1 Changes in the UK HE student population over time

Engineering and technology students

163,255

No. of students (2015 to 2016)

+1.0% ▲ 1 year change

+1.5% ▲ 5 year change

All students

2,285,825

No. of students (2015 to 2016)

+1.0% ▲ 1 year change

-8.8% ▼ 5 year change

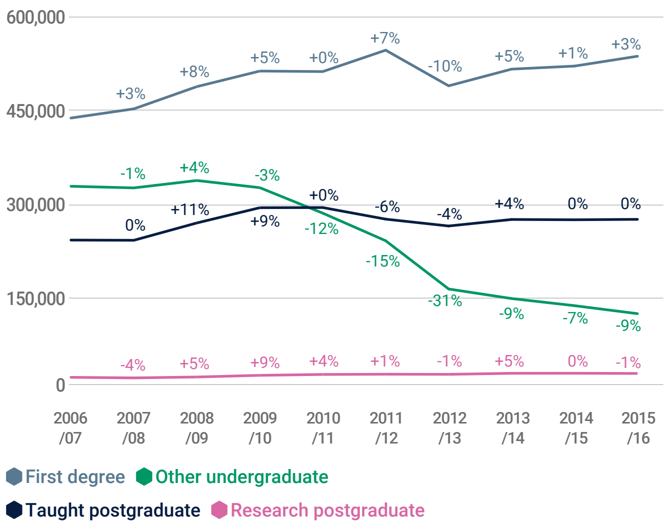
⬢ Engineering and technology students ⬢ All students

Source: HESA, student record 2015/16
For more detailed data on HE student population over time, see Figure 6.1 in our Excel resource.

Participation by mode and level of study

This increase in overall student numbers is not reflected across all levels and modes of study (Figure 6.2). There has been substantial growth in full time first degree and postgraduate research students (Figure 6.3). However, since 2011 to 2012, the number of other undergraduates has fallen markedly as has, to a lesser extent, the number studying postgraduate taught programmes on a part time basis, and this trend continued in 2015 to 2016. There has been an overall decline in part time studying, which decreased by 30% between 2011 to 2012 and 2015 to 2016. A high proportion of those studying at these levels do so on a part time basis, with 3 in 4 undergraduates not taking a first degree (75%) and nearly half of postgraduate taught students (48%) studying part time, compared with 25% of postgraduate research and 11% of first degree undergraduates.

Figure 6.2 Changes in the population of first year HE students in the UK by level of study, from the academic year starting in 2006 to 2015



Source: HESA, student record 2006/07–2015/16
To view this chart with student numbers see Figure 6.2 in our Excel resource.

Figure 6.3 Annual changes in the UK HE student population by level of study and mode from the academic year starting in 2012 to 2015

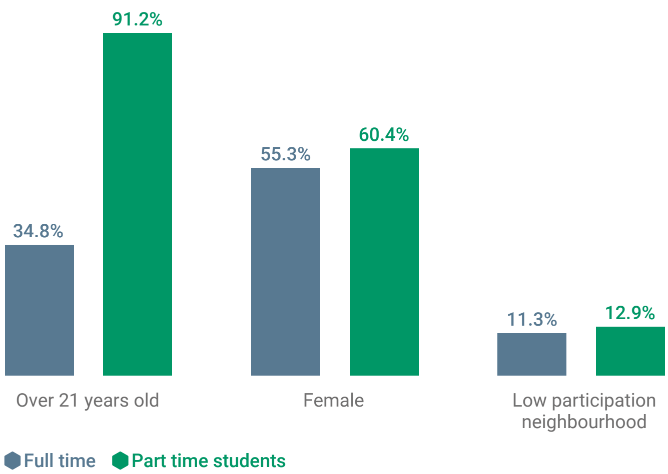
		2012 to 2013	2013 to 2014	2014 to 2015	2015 to 2016
First degree	Part time	-6% ▼	-8% ▼	-8% ▼	-5% ▼
	Full time	0%	2% ▲	0%	4% ▲
	Total	-1% ▼	0%	-1% ▼	3% ▲
Other undergraduate	Part time	-30% ▼	-16% ▼	-10% ▼	-10% ▼
	Full time	-27% ▼	-22% ▼	-11% ▼	-9% ▼
	Total	-29% ▼	-18% ▼	-10% ▼	-10% ▼
Taught postgraduate	Part time	-8% ▼	-3% ▼	-1% ▼	-2% ▼
	Full time	-6% ▼	3% ▲	0%	-1% ▼
	Total	-7% ▼	0%	-1% ▼	-1% ▼
Research postgraduate	Part time	-2% ▼	1% ▲	-1% ▼	-2% ▼
	Full time	0%	4% ▲	2% ▲	1% ▲
	Total	-1% ▼	3% ▲	1% ▲	0%
All degree levels	**Part time**	**-15%** ▼	**-8%** ▼	**-6%** ▼	**-5%** ▼
	Full time	**-2%** ▼	**1%** ▲	**0%**	**3%** ▲
	Total	**-6%** ▼	**-2%** ▼	**-1%** ▼	**1%** ▲

Source: HESA, student record 2012/13-2015/16
To view this table with student numbers, see Figure 6.3 in our Excel resource.

A number of reasons are thought to be responsible for the decline in part time studying. These include adjustments to the entitlement to funding for students studying for an equivalent or lower qualification (ELQ) in 2007 to 2008, the recession, general tightening of the budgets of employers (especially in the public sector), the substantial increases to tuition fees in 2012 to 2013, and restrictions in eligibility for student loans for some types of part time study.[6.10] In an effort to stymie this decline, in 2015 to 2016 the Equivalent or Lower Qualification (ELQ) policy was relaxed and exemptions were introduced. These allowed more learners studying a part time first degree in technology, engineering and computer science to access tuition fee loans in order to retrain.[6.11]

Constraints on part time study may have negative implications for the engineering pipeline. Flexible options enable a wider range of learners to study, which in turn expands the pool of potential HE-qualified employees in the labour force. The profile of part time HE students is often different from those studying full time, with many part time learners already in work, including those with existing qualifications who want to develop particular knowledge and expertise to support their professional development. For the employer, part time provision can enable its workforce to develop additional skills and knowledge while minimising the impact on day-to-day business, unlike releasing employees to study full time.

Figure 6.4 Age, gender and neighbourhood (POLAR3) of HE students in the UK in the academic year 2015 to 2016 by mode of study

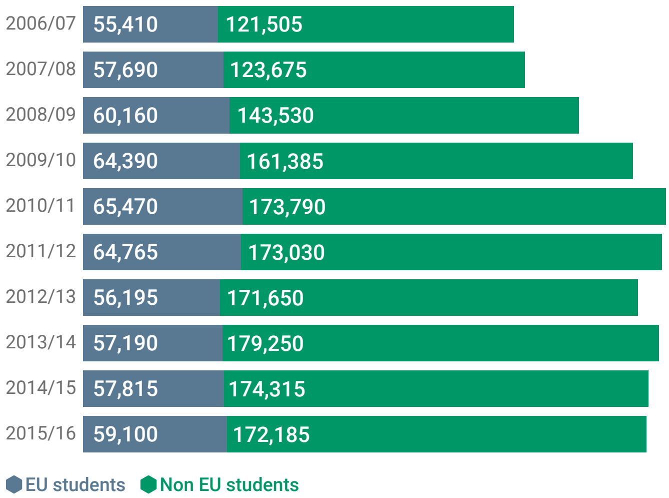


Source: HESA, student record 2015/16

The decline in part time HE provision also has a bearing on social mobility. As Figure 6.4 shows, a higher proportion of part time students are aged over 21, women and from low HE participation neighbourhoods compared with their full time peers. The flexibility that part time courses offer can provide an important second chance to pursue HE for those who might not have been able to go straight to university after school or need to balance other commitments with their studies.

Participation by domicile

Figure 6.5 International students entering UK HE by domicile in the academic years starting in 2006 to 2015

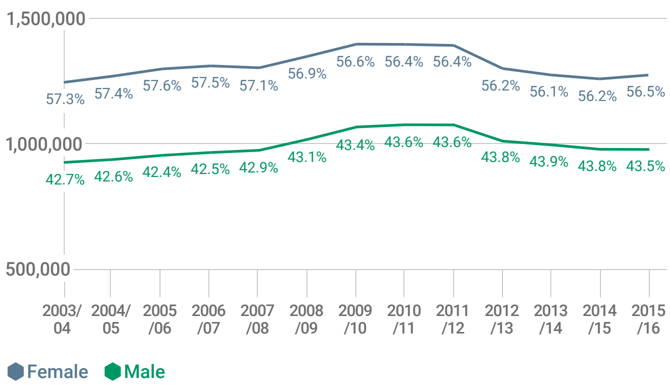


Source: HESA, student record 2006/07-2015/16

As discussed earlier in this section, the potential implications of the UK's departure from the EU for international student participation is a key concern. However, even before the EU referendum result, there was already evidence that the number of international students had begun to fall (Figure 6.5). First year non UK domiciled students in UK HE reached a peak of 239,260 in 2010 to 2011, but by 2015 to 2016, this had fallen to 231,285, just over a quarter of whom were from the EU. Although the subject of vigorous debate, research suggests that recent government immigration policy may have contributed to this decline. Modelling by the Higher Education Policy Institute (HEPI), for example, estimated that the April 2012 decision to remove international students' automatic right to work in the UK for 2 years after their studies was associated with a 20.3% decline in enrolment at undergraduate level.[6.12] Interestingly, HEPI also found that this decision was associated with a 7.2% increase in enrolment at postgraduate levels, although it noted that this rate could have been higher if the policy had not changed.

Participation by gender

Figure 6.6 All UK HE students by gender in the academic years starting in 2003 to 2015



Source: HESA, student record 2003/04-2015/16
To view this chart with student numbers, see Figure 6.6 in our Excel resource.

6.10 Bright Blue Campaign. 'Going part-time: Understanding and reversing the decline in part-time higher education', 2015.
6.11 BIS, 'A dual mandate for adult vocational education, a consultation paper', March 2015, p34.
6.12 HEPI, Kaplan International Pathways and London Economics. 'The determinants of international demand for UK higher education'. HEPI report 91, January 2017.

Although the general trend of a decline in student numbers has proportionally been larger among women than men, women continue to make up the majority of students in the UK (Figure 6.6). As discussed later in this chapter, there are also notable gender differences in progression and in outcomes. Higher proportions of women than men continue or qualify at first degree level, receive a first or upper second class degree, and pursue postgraduate studies.

In this context, the low proportion of women on engineering programmes at all levels of HE is worrying. Just 17.0% of all engineering and technology students in 2015 to 2016 were women, compared with 56.5% for the total HE student population. This underrepresentation is not new, in spite of numerous efforts to increase it. However, the increasing dominance of women participating in HE and their high performance academically suggest that they must remain a priority target group in terms of potential recruits to the engineering workforce in the longer term.

Participation by ethnicity

All ethnicity data in this chapter is presented for UK domiciled students only. This is because it is only compulsory to collect ethnicity data for UK domiciled students (although these students can choose not to disclose). Non white groups have been aggregated into a single black and minority ethnic (BME) group, though additional detail by the ethnic categories is presented where possible. While EngineeringUK recognises the limitations of this, it is a widely used approach to identify high level patterns of difference in relation to ethnicity.

The proportion of HE students who identified as black and minority ethnic (BME) has steadily increased over the last 12 years, with the largest growth among black students (Figure 6.7). Overall, higher proportions of BME students enrol in first degree undergraduate and taught postgraduate levels than at other undergraduate and research postgraduate levels.

There are notable differences between white and BME students in terms of whether they complete their degrees and what results they get. BME students are less likely to complete a degree or receive a first or upper second class qualification, although this varies considerably by ethnic group. These broad trends are also true of the engineering and technology student population.

Engineering and technology students in the UK are more ethnically diverse than students on average. A quarter of UK domiciled engineering and technology students in 2015 to 2016 identified as BME (25.2%), compared with 21.8% of UK domiciled HE students overall.

Nevertheless, it is evident, as is detailed later in this chapter, that ethnic diversity among engineering and technology students varies by level of study and discipline. As is the case for women, there is evidence that BME students are quite strongly overrepresented at postgraduate level relative to the proportion they comprise in first degree courses. Beyond the other benefits a more diverse supply would provide, there is a business case for actively encouraging BME students to enter undergraduate study, given the propensity of UK BME engineering graduates to pursue postgraduate studies.

Figure 6.7 All UK domiciled HE students studying in the UK by ethnic group in the academic years starting in 2003 to 2015

	White		BME total						
	No.	%	No.	%	*Black %*	*Asian %*	*Chinese %*	*Mixed %*	*Other %*
2003 to 2004	1,497,205	85.1%	261,890	14.9%	*4.4%*	*7.2%*	*0.9%*	*1.4%*	*0.9%*
2004 to 2005	1,518,815	84.5%	278,485	15.5%	*4.7%*	*7.3%*	*0.9%*	*1.7%*	*0.9%*
2005 to 2006	1,545,530	83.9%	296,885	16.1%	*5.0%*	*7.4%*	*0.9%*	*1.9%*	*0.9%*
2006 to 2007	1,549,310	83.4%	308,405	16.6%	*5.2%*	*7.5%*	*0.9%*	*2.1%*	*0.9%*
2007 to 2008	1,545,060	82.8%	321,085	17.2%	*5.4%*	*7.6%*	*0.9%*	*2.3%*	*1.0%*
2008 to 2009	1,594,980	82.2%	346,410	17.8%	*5.7%*	*7.7%*	*0.9%*	*2.5%*	*1.0%*
2009 to 2010	1,648,070	81.9%	365,030	18.1%	*5.9%*	*7.7%*	*0.9%*	*2.6%*	*1.0%*
2010 to 2011	1,646,875	81.6%	371,075	18.4%	*5.9%*	*7.8%*	*0.9%*	*2.8%*	*1.0%*
2011 to 2012	1,636,395	81.2%	378,490	18.8%	*6.0%*	*7.9%*	*0.9%*	*2.9%*	*1.1%*
2012 to 2013	1,507,845	80.4%	368,390	19.6%	*6.3%*	*8.3%*	*0.9%*	*3.1%*	*1.2%*
2013 to 2014	1,459,815	79.8%	370,415	20.2%	*6.4%*	*8.5%*	*0.9%*	*3.2%*	*1.2%*
2014 to 2015	1,418,685	79.0%	377,225	21.0%	*6.5%*	*8.9%*	*0.9%*	*3.4%*	*1.3%*
2015 to 2016	1,417,300	78.2%	395,690	21.8%	*6.7%*	*9.2%*	*0.9%*	*3.5%*	*1.5%*

Source: ECU, Equality in higher education statistical report 2017

Participation by POLAR3 quintile

Social mobility is desirable both as a social good and to benefit the economy. A study by the Organisation for Economic Co-operation and Development (OECD) warns that low social mobility can curb economic growth and constrain productivity. This implies that even from a narrow economic perspective, failure to tackle social disadvantage and low aspirations could have a negative impact on the UK's economic wellbeing.[6.13]

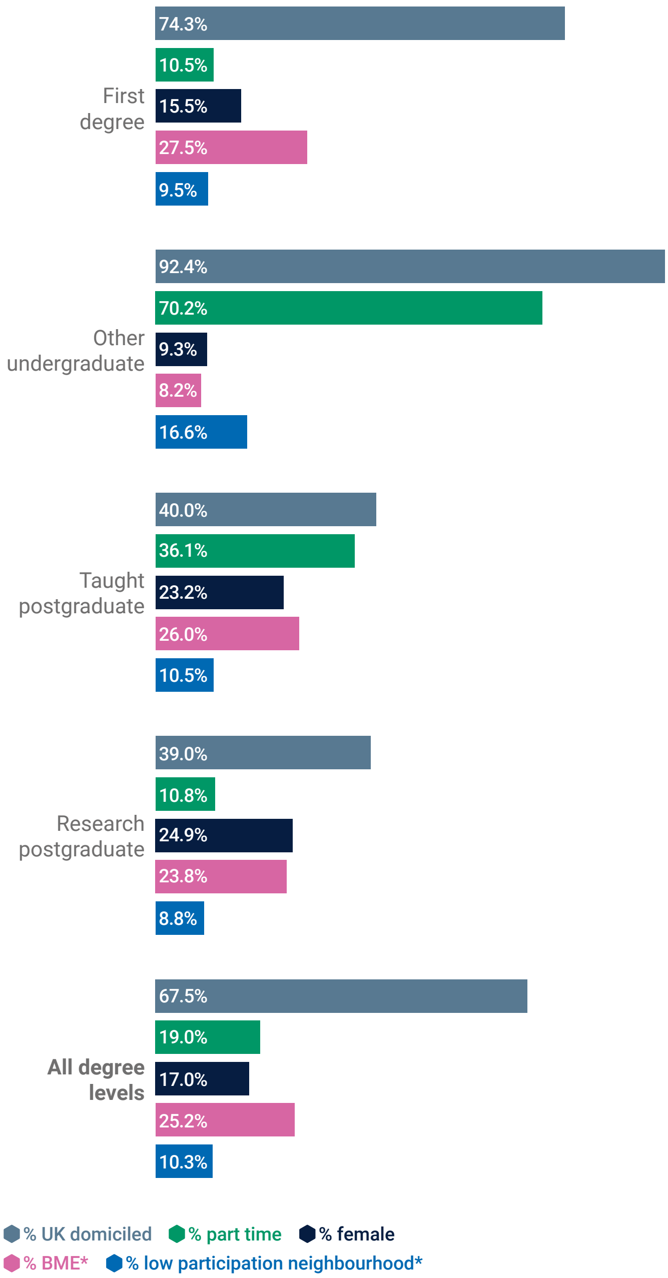
One of many metrics for measuring social mobility is the 'Participation of local areas' (POLAR3) methodology. POLAR3 classifies local areas or 'wards' in the UK into 5 groups or 'quintiles', based on the proportion of young people who enter HE aged 18 or 19 years old. These groups range from areas with the lowest participation ('most disadvantaged', known as quintile 1) up to areas with the highest rates ('most advantaged', referred to as quintile 5).

The proportion of young people from POLAR3 quintile 1 starting a first degree has increased but still remains low. In 2015 to 2016, just 11.3% of those studying full time and 13.9% of those studying part time came from such neighbourhoods.[6.14] The proportions studying engineering and technology, either full time or part time, from POLAR3 quintile 1 was even lower, at 8.5% and 11.9% respectively. This suggests that the engineering community has significant work to do to encourage participation by young people from disadvantaged backgrounds.

POLAR3 data is much more robust for first degree entrants than for other degree levels, available only for UK domiciled students and typically disaggregated by mode of study, subsequent sections of this chapter do not provide further analysis by POLAR3 quintile. However, it is worth bearing in mind that there is a complex interplay between social mobility and the characteristics that are covered, such as gender and ethnicity. In particular, the underrepresentation of white working class boys in higher education has recently been identified as a cause for concern in political communications.[6.15]

The proportion of students who were from POLAR3 quintile 1 is lower among those studying engineering and technology than students overall. This suggests that the engineering community has significant work to do to encourage participation by young people from disadvantaged backgrounds.

Figure 6.8 Domicile, mode, gender, neighbourhood (POLAR3) and ethnic background of engineering and technology students by degree level in the academic year starting in 2015 – UK



Source: HESA, student record 2015/16
* Applicable to UK domiciled students only

6.13 UKK. 'The economic role of UK universities', June 2015.
6.14 HESA. 'Widening participation summary: UK Performance Indicators 2015/16', February 2017.
6.15 OFFA. 'Who are white working class boys? The construction and measurement of identity'.

To more easily facilitate comparison by degree level, **Figure 6.8** provides a summary of engineering and technology students in the academic year 2015 to 2016 broken down by their domicile, mode of study, gender and broad ethnic group. As can be seen, there is wide variation of these characteristics by degree level. The remaining sections of this chapter is dedicated to detailed analysis for entrants and qualifiers at each degree level.

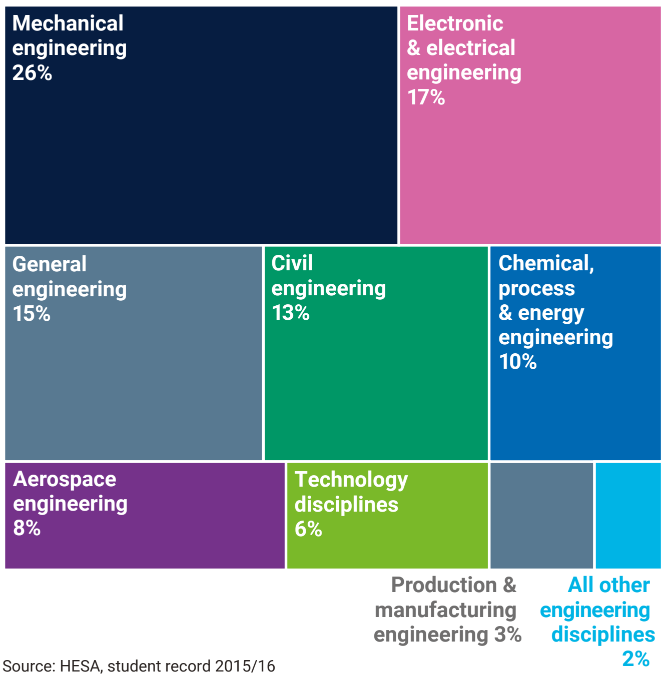
6.2 – Entrants to higher education

This section provides detailed analysis of HESA student record data. Because this is more complete than UCAS applicant and accepted applicants, which does not provide full coverage of international students (nor of postgraduate programmes), discussion of UCAS data has been omitted from this year's analysis.

First degree undergraduate entrants

There was an increase of 4.2% in the number of students starting a first degree undergraduate programme in engineering and technology in the academic year 2015 to 2016, from 35,845 in the previous year to 37,345. This represents 15.3% of all first year, first degree undergraduates studying a STEM subject. More than a quarter (26%) of these entrants studied mechanical engineering, 17% electronic and electrical engineering, and 15% general engineering (**Figure 6.9**).

Figure 6.9 Engineering and technology first degree entrants by discipline in the academic year starting in 2015 – UK



Source: HESA, student record 2015/16

The vast majority of engineering and technology first degree undergraduates were studying on a full time basis (91.6%), which was similar to the proportion studying a STEM subject overall (90.6%). In 13 of 18 engineering and technology disciplines, 90% or more of first year, first degree undergraduates studied full time. However, the proportion was much lower among those taking general engineering (74.9%), minerals technology (72.7%), production and manufacturing engineering (80.2%) 'other' engineering subjects (80.3%), and maritime technology (86.9%).

Strikingly, the proportion of engineering and technology first degree entrants from an international background was markedly larger than for any other STEM subject, at 27.6% compared with 13.2% across STEM overall (**Figure 6.10**). Over one-fifth of engineering and technology first degree entrants were from outside the EU (21.4%) and a further 6.2% from an EU country other than the UK. In fact, the proportion of international first degree entrants was higher for those studying engineering and technology than any other subject area in HE, apart from business and administrative studies (31.3%) (see Excel resource 6.10).

There is wide variation in where first degree entrants studying different engineering and technology courses come from. The proportion of first degree entrants who were from the UK was low in disciplines such as naval architecture (55.2%), electronic and electrical engineering (63.2%), maritime technology (51.1%) and biotechnology (50.0%), although overall student numbers for some of these were small. In contrast, comparatively high rates of first degree entrants studying general engineering (82.0%) or an 'other' engineering or technology subject (86.0% and 88.5% respectively) were from the UK. This suggests some subjects may be more attractive to international students – and potentially more vulnerable to any changes to immigration policy – than others.

27.6% of engineering and technology first degree entrants were from an international background, more than double the proportion across STEM overall (13.2%).

Figure 6.10 First degree entrants by STEM marker, subject area, mode of study, domicile, gender and ethnicity in the academic year starting 2015 – UK

	Mode		Domicile			Gender		
STEM subjects	**Full time %**	**Part time %**	**UK %**	**EU %**	**Non EU %**	**Male %**	**Female %**	**Total no.**
Agriculture and related subjects	98.6%	1.4%	91.2%	3.6%	5.2%	29.9%	70.1%	3,345
Architecture, building and planning	87.6%	12.4%	77.0%	6.2%	16.8%	62.6%	37.4%	10,325
Biological sciences	89.3%	10.7%	91.3%	4.6%	4.0%	38.4%	61.6%	61,670
Computer science	90.5%	9.5%	85.6%	7.4%	7.0%	85.1%	14.9%	27,255
Engineering and technology (H0-J9)	91.6%	8.4%	72.4%	6.2%	21.4%	84.0%	16.0%	37,335
Engineering disciplines (H0-H9)	91.4%	8.6%	72.2%	6.1%	21.7%	84.6%	15.4%	34,975
(H0) Broadly-based programmes	*100.0%*	*0.0%*	*72.4%*	*4.1%*	*23.4%*	*83.6%*	*16.4%*	*145*
(H1) General engineering	*74.9%*	*25.1%*	*82.0%*	*6.0%*	*12.0%*	*80.9%*	*19.1%*	*5,450*
(H2) Civil engineering	*91.7%*	*8.3%*	*71.1%*	*4.5%*	*24.4%*	*81.7%*	*18.3%*	*4,895*
(H3) Mechanical engineering	*95.3%*	*4.7%*	*71.7%*	*6.3%*	*22.1%*	*90.4%*	*9.6%*	*9,590*
(H4) Aerospace engineering	*98.4%*	*1.6%*	*76.2%*	*8.6%*	*15.2%*	*88.4%*	*11.6%*	*3,000*
(H5) Naval architecture	*100.0%*	*0.0%*	*55.2%*	*25.9%*	*19.0%*	*84.5%*	*15.5%*	*115*
(H6) Electronic and electrical engineering	*94.4%*	*5.6%*	*63.2%*	*6.2%*	*30.6%*	*87.2%*	*12.8%*	*6,520*
(H7) Production and manufacturing engineering	*80.2%*	*19.8%*	*79.0%*	*6.0%*	*15.0%*	*78.1%*	*21.9%*	*1,075*
(H8) Chemical, process and energy engineering	*98.7%*	*1.3%*	*70.5%*	*4.8%*	*24.7%*	*73.3%*	*26.7%*	*3,725*
(H9) Others in engineering	*80.3%*	*19.7%*	*86.0%*	*8.5%*	*5.5%*	*85.8%*	*14.2%*	*455*
Technology disciplines (J1-J9)	94.2%	5.8%	74.2%	8.6%	17.2%	75.3%	24.7%	2,360
(J1) Minerals technology	*72.7%*	*27.3%*	*75.8%*	*0.0%*	*24.2%*	*90.9%*	*9.1%*	*35*
(J2) Metallurgy	–	–	–	–	–	–	–	*15*
(J3) Ceramics and glass	–	–	–	–	–	–	–	*20*
(J4) Polymers and textiles	*100.0%*	*0.0%*	*49.2%*	*10.1%*	*40.7%*	*33.9%*	*66.1%*	*190*
(J5) Materials technology not otherwise specified	*95.7%*	*4.3%*	*62.9%*	*8.5%*	*28.6%*	*71.8%*	*28.2%*	*435*
(J6) Maritime technology	*86.9%*	*13.1%*	*51.1%*	*15.6%*	*33.3%*	*85.7%*	*14.3%*	*235*
(J7) Biotechnology	*100.0%*	*0.0%*	*50.0%*	*22.7%*	*27.3%*	*66.4%*	*33.6%*	*130*
(J9) Others in technology	*94.0%*	*6.0%*	*88.5%*	*6.1%*	*5.4%*	*82.0%*	*18.0%*	*1,300*
Mathematical sciences	89.8%	10.2%	82.6%	4.3%	13.0%	62.6%	37.4%	11,550
Medicine and dentistry	99.8%	0.2%	86.4%	2.7%	10.9%	42.5%	57.5%	9,620
Physical sciences	94.5%	5.5%	89.2%	4.2%	6.6%	58.0%	42.0%	23,425
Subjects allied to medicine	88.3%	11.7%	93.5%	2.8%	3.7%	18.7%	81.3%	58,005
Veterinary science	100.0%	0.0%	82.1%	2.3%	15.5%	19.3%	80.7%	1,210
Total STEM	**90.6%**	**9.4%**	**86.8%**	**4.7%**	**8.5%**	**49.9%**	**50.1%**	**243,735**
Total non STEM	**91.8%**	**8.2%**	**82.3%**	**5.8%**	**11.9%**	**39.0%**	**61.0%**	**298,710**
All subjects	**91.3%**	**8.7%**	**84.4%**	**5.3%**	**10.4%**	**43.9%**	**56.1%**	**542,445**

Source: HESA, student record 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
Ethnicity figures are restricted to UK domiciled entrants. For all other figures, entrants from all domiciles have been included.
To view this table with student numbers, by disability status, and for non STEM subjects, see Figure 6.10 in our Excel resource.

Ethnic group (UK domiciled)						
White %	BME %	Asian %	Black %	Mixed %	Other %	Total no.
93.2%	6.8%	2.3%	1.8%	2.5%	0.2%	3,035
75.1%	24.9%	10.9%	7.4%	3.9%	2.7%	7,865
77.8%	22.2%	9.5%	6.9%	4.5%	1.4%	55,905
70.3%	29.7%	16.1%	8.2%	3.6%	1.8%	23,050
68.6%	31.4%	16.3%	8.5%	3.9%	2.7%	26,720
68.0%	32.0%	16.8%	8.5%	3.9%	2.8%	24,980
25.2%	74.8%	48.0%	17.6%	3.9%	4.9%	105
69.2%	30.8%	15.4%	8.9%	3.6%	2.9%	4,410
67.4%	32.6%	15.6%	9.3%	4.0%	3.6%	3,435
71.4%	28.6%	16.2%	6.5%	3.7%	2.2%	6,800
62.2%	37.8%	21.2%	7.6%	5.1%	3.8%	2,270
93.7%	6.3%	0.0%	1.6%	3.2%	1.6%	65
67.3%	32.7%	17.1%	9.7%	3.6%	2.3%	4,065
84.0%	16.0%	8.7%	3.7%	3.1%	0.6%	840
59.4%	40.6%	21.0%	11.6%	4.1%	3.9%	2,610
73.8%	26.2%	11.4%	9.6%	3.1%	2.1%	385
76.6%	23.4%	8.4%	8.8%	4.8%	1.5%	1,740
84.0%	16.0%	12.0%	0.0%	4.0%	0.0%	25
–	–	–	–	–	–	5
–	–	–	–	–	–	15
79.6%	20.4%	7.5%	6.5%	6.5%	0.0%	95
73.4%	26.6%	12.9%	5.9%	5.5%	2.6%	270
88.4%	11.6%	1.6%	4.1%	4.9%	1.6%	120
71.9%	28.1%	9.4%	12.5%	4.7%	1.6%	65
75.9%	24.1%	8.1%	10.2%	4.4%	1.4%	1,145
75.6%	24.4%	15.8%	3.6%	3.8%	1.2%	9,440
62.4%	37.6%	26.0%	3.8%	5.3%	2.5%	8,230
84.3%	15.7%	7.8%	3.1%	3.9%	0.9%	20,740
72.4%	27.6%	12.4%	11.1%	2.7%	1.4%	53,825
93.1%	6.9%	3.4%	0.2%	2.9%	0.4%	995
74.5%	**25.5%**	**12.5%**	**7.6%**	**3.7%**	**1.6%**	**209,800**
76.0%	**24.0%**	**10.0%**	**7.9%**	**4.5%**	**1.5%**	**243,470**
75.3%	**24.7%**	**11.2%**	**7.8%**	**4.2%**	**1.5%**	**453,265**

Out of all subject areas, engineering and technology had the second lowest proportion of first degree entrants who were women in the academic year starting in 2015.

The proportion of women entering first degree undergraduate engineering and technology subjects increased from 15.1% in the academic year starting in 2014 to 16.0% in the following year (**Figure 6.10**). However, out of all subject areas, engineering and technology had the second lowest proportion of first degree entrants who were women in the academic year starting in 2015 – only computer science had a lower proportion, at 14.9%. This contrasts with the number of women starting STEM first degrees (50.1%) and first degrees overall (56.1%). There is clearly a lot of work to do to attract women into engineering and technology.

Having said this, women were better represented in certain engineering and technology disciplines than others. Women accounted for two-thirds (66.1%) of first degree entrants in polymers and textiles and a third (33.6%) in biotechnology, though overall numbers on these courses were relatively small. At the other end of the scale, the proportion of first degree entrants in mechanical engineering who were women was very low (9.6%).

In respect of ethnicity, engineering and technology was more diverse than every subject area other than medicine and dentistry, with 31.4% of UK domiciled first degree entrants coming from a BME background. There were particularly high proportions of first degree entrants with a BME background entering aerospace engineering (37.8%) and chemical, process and energy engineering (40.6%). However, on average, BME first degree qualifiers consistently attain lower degree outcomes than white qualifiers (see section 6.3).

Higher National Certificates (HNCs), Higher National Diplomas (HNDs) and foundation degrees

Higher National Certificates (HNCs) and Diplomas (HNDs) and foundation degrees are HE vocational qualifications designed to allow students to enhance their career prospects, and in some cases to gain professional registration and/or to study honours degrees and higher HE programmes. They are delivered or accredited by higher education institutions, further education colleges and a range of work-based learning and other providers.

HNCs are level 4 qualifications equivalent to the first year of study on an honours degree programme. They usually take one year to complete on a full time basis and 2 years when studied part time.

HNDs are level 5 qualifications, corresponding to the first 2 years of study on an honours degree programme, and take 2 years to complete on a full time basis. Students who successfully complete either an HNC or HND may progress to the second or third year of a related honours degree. These qualifications are designed to enable people from non academic educational backgrounds to progress into HE. Admission is assessed individually, based on previous qualifications and relevant industry experience.

Foundation degrees are level 5 qualifications, equivalent to the first 2 years' study of an honours degree. They are work-based qualifications, so they enable learners to remain in paid employment while studying. Foundation degrees are developed in close collaboration with employers, and in many cases are in applied subjects.

HESA classifies HNCs, HNDs and foundation courses as 'other undergraduate' programmes, along with all other undergraduate courses apart from first degrees (otherwise known as bachelor's degrees). HESA records all such courses where they are offered by an HE institution or a provider that supplies them with student data, but omits HNC and HND courses offered by other types of provider.

Figure 6.11 Other undergraduate entrants in the UK by STEM subject area and course aim in the academic year starting in 2015 – UK

	HNC		HND		Foundation degree		All 'other undergraduate' course aims		Total
	No.	%	No.	%	No.	%	No.	%	No.
Agriculture and related subjects	225	3.6%	225	7.1%	1,150	6.6%	2,605	3.2%	4,205
Architecture, building and planning	870	13.9%	125	3.9%	280	1.6%	525	0.6%	1,800
Biological sciences	335	5.4%	295	9.3%	1,485	8.5%	2,655	3.2%	4,775
Computer science	270	4.3%	425	13.3%	730	4.2%	985	1.2%	2,410
Engineering and technology	2,755	44.1%	595	18.6%	1,915	11.0%	1,885	2.3%	7,150
Mathematical sciences	0	0.0%	0	0.1%	0	0.0%	380	0.5%	380
Medicine and dentistry	0	0.0%	0	0.0%	0	0.0%	70	0.1%	70
Physical sciences	85	1.4%	45	1.5%	250	1.4%	645	0.8%	1,025
Subjects allied to medicine	95	1.5%	60	1.8%	2,470	14.1%	27,280	33.1%	29,900
Veterinary science	0	–	0	–	0	–	15	–	15
Total STEM	**4,630**	**74.2%**	**1,775**	**55.6%**	**8,280**	**47.4%**	**37,045**	**44.9%**	**51,730**
All subjects	**6,245**	**100.0%**	**3,195**	**100.0%**	**17,465**	**100.0%**	**82,505**	**100.0%**	**131,485**

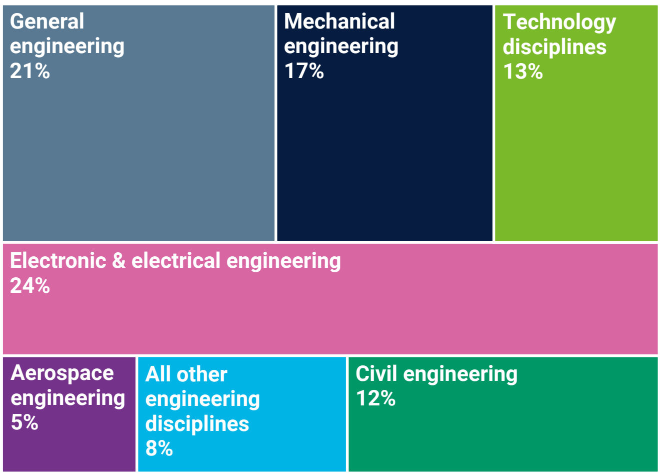
Source: HESA, student record 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.

Other undergraduate entrants

Figure 6.11 shows that, of the courses covered by HESA data, there was a 2.5% increase in students entering HNC programmes in the academic year starting in 2015 (6,245) compared with the previous year. Nearly three-quarters of these (74.2%) were studying STEM subjects. Engineering and technology was one of the most popular HNC subject areas, accounting for 44.1% of all entrants. However, comparatively fewer entrants started engineering and technology HND courses, continuing the steady decline in numbers in recent years. Over half of the 3,195 entrants enrolled on HND programmes started studies in STEM subjects but only 18.6% in engineering and technology. The proportion of students enrolling in an engineering and technology related foundation degree in 2015 to 2016 was even lower, at just 11.0% of the total of 17,465.

The number of engineering and technology 'other undergraduate' entrants in 2015 to 2016 declined 10.0% compared with the previous year, reflecting the broader downward trend at this degree level. Nearly a quarter (24%) of engineering and technology entrants into 'other undergraduate' programmes (including, but not limited to HNC, HND and foundation degrees) took up studies in electronic and electrical engineering, and one-fifth (21%) started a general engineering programme. Mechanical engineering was also a popular subject (17%) and 13% chose to study technology-related disciplines, which is more than twice the proportion at first degree level (**Figure 6.12**).

Figure 6.12 Engineering and technology other undergraduate entrants in the UK by discipline in the academic year starting in 2015



Source: HESA, student record 2015/16

Students starting other undergraduate engineering and technology programmes in 2015 to 2016 had a very different profile in respect of mode, domicile, gender and ethnicity to those studying for a first degree. Two-thirds (66%) of these entrants chose to study part-time and 88.8% were from the UK (**Figure 6.13**). This may reflect the different course aims of other undergraduate degrees and the tendency for students in these programmes to be both older than students starting 'traditional' first degrees and potentially already in employment.[6.16]

6.16 ECU. 'Equality in higher education: statistical report 2016', November 2016

Figure 6.13 Students starting 'other undergraduate' courses in the academic year from 2015 to 2016, by STEM marker, subject area, mode of study, domicile, gender and ethnicity – UK

	Mode of study		Domicile			Gender		
STEM subjects	**Full time %**	**Part time %**	**UK %**	**EU %**	**Non EU %**	**Male %**	**Female %**	**Total no.**
Agriculture and related subjects	35.9%	64.1%	98.0%	1.2%	0.7%	48.6%	51.4%	4,225
Architecture, building and planning	39.9%	60.1%	83.1%	3.6%	13.3%	71.0%	29.0%	2,335
Biological sciences	47.3%	52.7%	91.9%	1.9%	6.2%	43.1%	56.9%	4,835
Computer science	42.4%	57.6%	83.6%	12.2%	4.2%	80.4%	19.6%	2,450
Engineering and technology (H0-J9)	34.0%	66.0%	88.8%	1.6%	9.6%	89.8%	10.2%	7,180
Engineering disciplines (H0-H9)	31.8%	68.2%	90.9%	1.5%	7.6%	90.1%	9.9%	6,235
(H0) Broadly-based programmes	*80.8%*	*19.2%*	*19.2%*	*0.0%*	*80.8%*	*82.7%*	*17.3%*	*50*
(H1) General engineering	*41.7%*	*58.3%*	*84.2%*	*2.4%*	*13.4%*	*90.0%*	*10.0%*	*1,525*
(H2) Civil engineering	*17.8%*	*82.2%*	*93.1%*	*0.4%*	*6.5%*	*82.8%*	*17.2%*	*845*
(H3) Mechanical engineering	*18.5%*	*81.5%*	*94.8%*	*0.9%*	*4.3%*	*92.9%*	*7.1%*	*1,205*
(H4) Aerospace engineering	*99.2%*	*0.8%*	*98.1%*	*1.4%*	*0.6%*	*93.4%*	*6.6%*	*365*
(H5) Naval architecture	–	–	–	–	–	–	–	*20*
(H6) Electronic and electrical engineering	*19.2%*	*80.8%*	*94.8%*	*1.4%*	*3.8%*	*93.1%*	*6.9%*	*1,745*
(H7) Production and manufacturing engineering	*58.9%*	*41.1%*	*94.7%*	*3.2%*	*2.1%*	*92.2%*	*7.8%*	*280*
(H8) Chemical, process and energy engineering	*13.1%*	*86.9%*	*91.9%*	*2.0%*	*6.1%*	*74.7%*	*25.3%*	*100*
(H9) Others in engineering	*40.2%*	*59.8%*	*55.9%*	*3.9%*	*40.2%*	*72.5%*	*27.5%*	*100*
Technology disciplines (J1-J9)	48.2%	51.8%	75.2%	2.3%	22.5%	87.3%	12.7%	945
(J1) Minerals technology	*0.0%*	*100.0%*	*100.0%*	*0.0%*	*0.0%*	*92.0%*	*8.0%*	*110*
(J2) Metallurgy	–	–	–	–	–	–	–	*0*
(J3) Ceramics and glass	–	–	–	–	–	–	–	*0*
(J4) Polymers and textiles	–	–	–	–	–	–	–	*20*
(J5) Materials technology not otherwise specified	*50.0%*	*50.0%*	*95.6%*	*0.0%*	*4.4%*	*68.2%*	*31.8%*	*45*
(J6) Maritime technology	*59.9%*	*40.1%*	*43.8%*	*2.6%*	*53.6%*	*96.3%*	*3.7%*	*380*
(J7) Biotechnology	–	–	–	–	–	–	–	*0*
(J9) Others in technology	*48.0%*	*52.0%*	*97.2%*	*1.3%*	*1.5%*	*80.5%*	*19.5%*	*395*
Mathematical sciences	34.0%	66.0%	79.5%	4.1%	16.5%	62.6%	37.4%	415
Medicine and dentistry	74.4%	25.6%	88.1%	7.4%	4.5%	18.2%	81.8%	175
Physical sciences	34.3%	65.7%	78.0%	8.4%	13.6%	61.1%	38.9%	1,175
Subjects allied to medicine	9.1%	90.9%	98.1%	0.7%	1.2%	16.6%	83.4%	42,775
Veterinary science	–	–	–	–	–	–	–	15
Total STEM	**19.5%**	**80.5%**	**95.0%**	**1.7%**	**3.3%**	**34.0%**	**66.0%**	**65,585**
Total non STEM	**26.5%**	**73.5%**	**81.2%**	**3.7%**	**15.0%**	**35.4%**	**64.6%**	**65,875**
All subjects	**23.0%**	**77.0%**	**88.1%**	**2.7%**	**9.2%**	**34.7%**	**65.3%**	**131,460**

Source: HESA, student record 2015/16
Ethnicity figures are restricted to UK domiciled entrants. For all other figures, entrants from all domiciles have been included.
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with student numbers, by disability status, and for non STEM subjects see Figure 6.13 in our Excel resource.

Ethnic group (UK domiciled)						
White %	BME %	Asian %	Black %	Mixed %	Other %	Total no.
96.4%	3.6%	0.8%	1.5%	1.1%	0.2%	3,960
87.9%	12.1%	4.3%	4.6%	2.0%	1.3%	1,895
79.8%	20.2%	6.0%	8.7%	4.1%	1.5%	4,285
81.0%	19.0%	7.3%	7.5%	2.6%	1.6%	2,005
90.9%	9.1%	3.7%	2.6%	1.7%	1.1%	6,070
90.4%	9.6%	4.0%	2.7%	1.7%	1.2%	5,380
–	–	–	–	–	–	10
87.4%	12.6%	5.3%	3.3%	1.8%	2.2%	1,105
86.8%	13.2%	4.0%	4.3%	2.8%	2.2%	775
94.3%	5.7%	2.4%	0.9%	1.8%	0.5%	1,105
94.1%	5.9%	3.5%	1.5%	0.9%	0.0%	340
–	–	–	–	–	–	20
95.8%	4.2%	1.4%	1.5%	1.1%	0.2%	1,615
60.0%	40.0%	19.9%	12.4%	2.6%	5.3%	265
88.9%	11.1%	5.6%	3.3%	2.2%	0.0%	90
96.5%	3.5%	1.8%	0.0%	1.8%	0.0%	55
94.2%	5.8%	1.4%	2.3%	1.9%	0.4%	690
97.3%	2.7%	0.9%	0.0%	1.8%	0.0%	110
–	–	–	–	–	–	0
–	–	–	–	–	–	0
–	–	–	–	–	–	10
92.9%	7.1%	2.3%	2.3%	2.3%	2.3%	45
96.9%	3.1%	1.2%	0.6%	1.2%	0.6%	165
–	–	–	–	–	–	0
92.6%	7.4%	1.6%	3.3%	2.2%	0.3%	365
72.8%	27.2%	11.4%	9.6%	3.1%	3.1%	325
71.8%	28.2%	15.5%	2.1%	8.5%	2.1%	140
84.3%	15.7%	7.3%	3.9%	2.3%	2.1%	895
81.0%	19.0%	8.8%	7.6%	1.7%	0.9%	40,450
–	–	–	–	–	–	15
83.1%	**16.9%**	**7.4%**	**6.6%**	**1.9%**	**1.0%**	**60,035**
85.0%	**15.0%**	**6.0%**	**5.4%**	**2.4%**	**1.2%**	**51,405**
84.0%	**16.0%**	**6.7%**	**6.0%**	**2.1%**	**1.1%**	**111,440**

Although a much higher proportion of other undergraduate entrants overall were women (65.3%) compared with first degree entrants 56.1%), this was not the case for engineering and technology, with only 10.2% of them being women (**Figure 6.13**) compared with 16.0% of first degree entrants. Likewise, UK domiciled entrants into engineering and technology 'other undergraduate' programmes were less ethnically diverse than those on first degree courses, with only 9.1% from a BME background. One exception to this was in production and manufacturing engineering, where 40.0% identified as BME, although total student numbers in this discipline were relatively low (265).

Taught postgraduate entrants

All taught postgraduate figures reported in this chapter exclude those studying for integrated masters (MEng) courses, which are included instead within the first degree data.

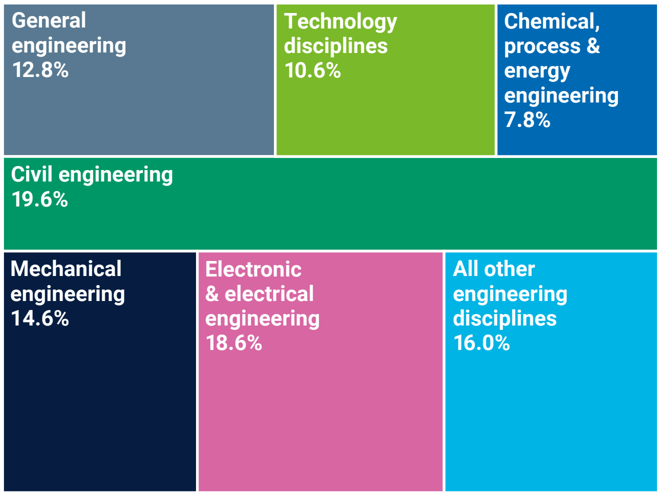
Taught postgraduate study (including many masters courses) accounts for a significant proportion of UK higher education and attracts many international students. Two-fifths (40.8%) of the 280,000 or so students who started taught postgraduate studies in the academic year starting in 2015 were classified as international. This is a much higher proportion than among both first degree and other undergraduate levels (25.7% and 7.65% respectively).

Over one-third (35.9%) of entrants to postgraduate taught courses in 2015 to 2016 studied STEM subjects, with 16.4% of them (16,570) enrolling in engineering and technology courses – a 3.5% decline compared with the previous year.

One-fifth of the students starting engineering and technology taught postgraduate courses went into civil engineering (19.6%) and a similar proportion (18.6%) started electronic and electrical engineering studies (**Figure 6.14**). Mechanical engineering was also a popular subject (14.6%), while just over one-tenth (10.6%) of entrants studied a technology-related discipline.

Overall, more than two thirds of engineering and technology postgraduate taught entrants were international students – and in some disciplines this was as high as 80%.

Figure 6.14 Engineering and technology taught postgraduate entrants by discipline in the academic year starting in 2015 – UK



Source: HESA, student record 2015/16

Although a significant proportion (40.8%) of postgraduate taught entrants are international students, this figure is far higher for those studying engineering and technology subjects. As **Figure 6.16** shows, in the academic year starting in 2015, over two-thirds of engineering and technology entrants to postgraduate taught programmes were international, with 14.3% from other EU nations, 54.6% from outside the EU and just 31.1% from the UK. By comparison, almost 3 in 5 (59.2%) of the overall taught postgraduate cohort were UK domiciled, with 7.8% from other EU nations and the remaining third (33.0%) from the rest of the world.

Even more striking is that STEM taught postgraduates tended to be less international than the overall taught postgraduate cohort, with just one-third (33.4%) of those starting in 2015 to 2016 coming from outside the UK. Indeed, engineering and technology had the lowest proportion of UK domiciled taught postgraduates (31.1%) of all HE subject areas with the exception of business and administrative studies (28.2% UK domiciled).

The proportion of taught postgraduate entrants from an international background was particularly high among those studying electronic and electrical engineering and production and manufacturing engineering, exceeding 4 out of every 5 students (83.0% and 81.5% respectively). This proportion was even higher in naval architecture, ceramics and glass, polymers and textiles, and 'materials technology not otherwise specified', but overall student numbers within these disciplines were also small.

This reflects great success in terms of 'exporting' UK engineering postgraduate education to international students, but also means that these courses may not be viable if such high levels of international participation are not sustained. It also implies that the supply of engineering and technology taught postgraduates may be affected by any changes in international student mobility.

As can be seen in Figure 6.16, the profile of students starting engineering and technology postgraduate taught courses differed markedly from other subjects in respect of how they chose to study. Just one in 5 studied on a part-time basis, which was considerably lower than for most other STEM subjects. The higher the number of international students, the higher the proportion of full-time study, with EU and non-EU students being more likely to study full-time than their UK domiciled peers.

Figure 6.16 shows how the gender and ethnicity of postgraduate taught students starting courses in the academic year to 2015 varied by subject. Women accounted for around a quarter (25.2%) of taught postgraduate students in engineering, similar to the proportion seen in previous years. In every engineering discipline, the proportion of entrants who were women was higher at postgraduate taught level than first degree undergraduate level, with the sole exception of naval architecture. This difference was most marked in biotechnology, where women comprised one-third of first degree entrants (33.6%) but 53.4% of those at postgraduate taught level. This suggests that female engineering and technology graduates are more likely to pursue postgraduate study than their male peers, a trend that can be seen in most other STEM subjects as well.

Nevertheless, women are severely underrepresented in engineering and technology across all levels of HE, including at postgraduate taught level. Biotechnology and polymers and textiles were the only engineering and technology disciplines for which the majority of postgraduate taught entrants were women in the academic year starting in 2015. Less than 1 in 5 of entrants were women for subjects such as mechanical engineering (13.3%), aerospace engineering (15.2%), naval architecture (9.4%), minerals technology (16.3%) and 'others in engineering' (19.2%).

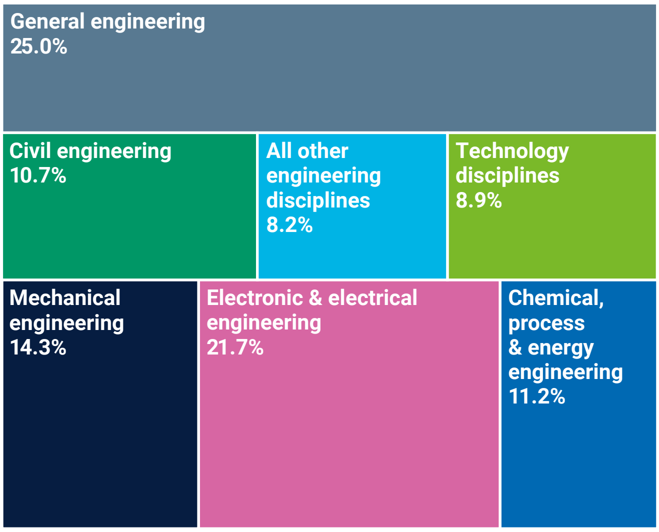
However, in terms of ethnicity, postgraduate taught entrants in engineering and technology in 2015 to 2016 were more ethnically diverse than those in most other STEM subject areas, with 29.0% from a BME background. Only computer science (32.6%) and medicine and dentistry (35.6%) had higher proportions of BME entrants. The proportion of postgraduate taught entrants from a BME background was particularly high in electronic and electrical engineering (42.2%) and chemical, process and energy engineering (47.4%).

Research postgraduate entrants

Research postgraduate entrants comprise those starting doctorate degrees, a course that awards relevant provider credits, masters degrees or other higher degrees that meet the criteria for a research-based higher degree, as defined by HESA. Nearly two-thirds (62.6%) of the 35,975 research postgraduate degree entrants in the academic year starting in 2015 enrolled on a STEM-related programme, with 12.4% in engineering and technology. These 4,460 engineering and technology postgraduate research entrants represent a 9.2% decrease compared with the previous year. Due to this relatively small total, a breakdown by ethnic group is not presented here.

Of those who entered engineering and technology related research postgraduate studies in 2015 to 2016, a quarter (25.0%) did so in general engineering and over one-fifth (21.7%) in electronic and electrical engineering (Figure 6.15). The other subjects with the highest number of entrants were mechanical engineering (14.3%), civil engineering (10.7%) and chemical, process and energy engineering (11.2%).

Figure 6.15 Students starting engineering and technology research postgraduate courses in the academic year starting in 2015 by discipline – UK



Source: HESA, student record 2015/16

Figure 6.17 shows the variation in mode of study and domicile of research postgraduate students. As with taught postgraduate entrants, a high proportion of all postgraduate research entrants are international students and this is particularly pronounced among those studying engineering and technology subjects. In the academic year starting in 2015, just 38.9% of research postgraduate entrants in engineering and technology subjects were from the UK, compared with 56.0% across all subjects. Only business and administrative studies had a similarly small proportion of UK entrants, and the percentage was the lowest of all STEM subject areas. This again underscores the vulnerability of the supply of engineering and technology postgraduates to any changes that might affect the mobility of international students.

Similarly, while much higher rates of research postgraduate entrants study on a full time basis compared with taught postgraduates in general, this difference was more pronounced among engineering and technology students. Just 7.6% of research postgraduate entrants in engineering and technology studied part-time, compared with 17.8% across all subjects and 12.1% in STEM.

6.16 ECU. 'Equality in higher education: statistical report 2016', November 2016

Figure 6.16 Students starting taught postgraduate courses in the academic year starting in 2015 by STEM marker, subject area, mode, domicile, gender and ethnicity 2015 to 2016 – UK

	Mode of study		Domicile			Gender		
STEM subjects	Full time %	Part time %	UK %	EU %	Non EU %	Male %	Female %	Total no.
Agriculture and related subjects	59.1%	40.9%	59.0%	10.6%	30.3%	39.4%	60.6%	1,530
Architecture, building and planning	65.1%	34.9%	57.9%	7.0%	35.0%	55.1%	44.9%	8,615
Biological sciences	66.8%	33.2%	74.5%	8.8%	16.6%	32.0%	68.0%	13,865
Computer science	78.3%	21.7%	43.8%	11.9%	44.3%	71.4%	28.6%	7,665
Engineering and technology (H0-J9)	80.1%	19.9%	31.1%	14.3%	54.6%	74.8%	25.2%	16,570
Engineering disciplines (H0-H9)	80.8%	19.2%	29.8%	14.6%	55.6%	76.3%	23.7%	14,825
(H0) Broadly-based programmes	*–*	*–*	*–*	*–*	*–*	*–*	*–*	*0*
(H1) General engineering	*56.6%*	*43.4%*	*50.4%*	*13.0%*	*36.5%*	*77.3%*	*22.7%*	*2,125*
(H2) Civil engineering	*84.5%*	*15.5%*	*30.0%*	*13.9%*	*56.1%*	*69.4%*	*30.6%*	*3,245*
(H3) Mechanical engineering	*79.8%*	*20.2%*	*30.6%*	*17.3%*	*52.1%*	*86.7%*	*13.3%*	*2,425*
(H4) Aerospace engineering	*87.3%*	*12.7%*	*31.0%*	*31.7%*	*37.3%*	*84.8%*	*15.2%*	*1,040*
(H5) Naval architecture	*100.0%*		*17.6%*	*34.1%*	*48.2%*	*90.6%*	*9.4%*	*85*
(H6) Electronic and electrical engineering	*91.1%*	*8.9%*	*17.0%*	*8.3%*	*74.7%*	*76.2%*	*23.8%*	*3,085*
(H7) Production and manufacturing engineering	*84.7%*	*15.3%*	*18.5%*	*16.5%*	*65.0%*	*69.2%*	*30.8%*	*1,090*
(H8) Chemical, process and energy engineering	*90.7%*	*9.3%*	*29.3%*	*11.9%*	*58.8%*	*69.6%*	*30.4%*	*1,295*
(H9) Others in engineering	*46.8%*	*53.2%*	*42.3%*	*15.9%*	*41.8%*	*80.8%*	*19.2%*	*430*
Technology disciplines (J1-J9)	74.1%	25.9%	41.9%	11.8%	46.3%	61.9%	38.1%	1,745
(J1) Minerals technology	*81.6%*	*18.4%*	*82.0%*	*4.0%*	*14.0%*	*83.7%*	*16.3%*	*50*
(J2) Metallurgy	*89.1%*	*10.9%*	*29.0%*	*7.5%*	*63.4%*	*75.0%*	*25.0%*	*90*
(J3) Ceramics and glass	*100.0%*		*3.8%*	*7.7%*	*88.5%*	*69.2%*	*30.8%*	*25*
(J4) Polymers and textiles	*93.2%*	*6.8%*	*13.5%*	*3.4%*	*83.1%*	*33.3%*	*66.7%*	*175*
(J5) Materials technology not otherwise specified	*92.6%*	*7.4%*	*12.3%*	*11.2%*	*76.6%*	*67.5%*	*32.5%*	*270*
(J6) Maritime technology	*86.5%*	*13.5%*	*31.6%*	*32.9%*	*35.5%*	*76.1%*	*23.9%*	*155*
(J7) Biotechnology	*98.2%*	*1.8%*	*29.8%*	*15.2%*	*55.0%*	*46.6%*	*53.4%*	*330*
(J9) Others in technology	*42.3%*	*57.7%*	*70.8%*	*9.0%*	*20.2%*	*67.9%*	*32.1%*	*650*
Mathematical sciences	86.5%	13.5%	33.7%	14.1%	52.2%	58.6%	41.4%	2,645
Medicine and dentistry	47.6%	52.4%	71.9%	5.9%	22.2%	36.7%	63.3%	6,740
Physical sciences	83.2%	16.8%	52.9%	10.5%	36.6%	52.8%	47.2%	5,245
Subjects allied to medicine	23.4%	76.6%	89.1%	2.9%	8.0%	22.6%	77.4%	37,535
Veterinary science	16.3%	83.7%	87.7%	6.6%	5.8%	28.8%	71.2%	655
Total STEM	**53.2%**	**46.8%**	**66.6%**	**7.6%**	**25.8%**	**42.7%**	**57.3%**	**101,060**
Total non STEM	**70.5%**	**29.5%**	**55.1%**	**7.8%**	**37.0%**	**37.3%**	**62.7%**	**180,960**
All subjects	**64.3%**	**35.7%**	**59.2%**	**7.8%**	**33.0%**	**39.2%**	**60.8%**	**282,020**

Source: HESA, student record 2015/16
Ethnicity figures are restricted to UK domiciled entrants. For all other figures, entrants from all domiciles have been included.
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with student numbers, by disability status, and for non STEM subjects, see Figure 6.16 in our Excel resource.

Ethnic group (UK domiciled)						
White %	BME %	*Asian %*	*Black %*	*Mixed %*	*Other %*	Total no.
91.7%	8.3%	3.4%	2.9%	1.7%	0.3%	870
79.9%	20.1%	9.1%	5.7%	3.3%	1.9%	4,900
80.6%	19.4%	8.8%	5.7%	3.5%	1.4%	10,110
67.4%	32.6%	16.8%	10.2%	3.0%	2.6%	3,165
71.0%	29.0%	13.7%	8.9%	3.2%	3.3%	4,980
69.0%	31.0%	14.9%	9.4%	3.2%	3.5%	4,285
–	–	–	–	–	–	*0*
79.1%	*20.9%*	*10.6%*	*6.0%*	*2.7%*	*1.6%*	*1,020*
69.1%	*30.9%*	*13.0%*	*10.2%*	*3.4%*	*4.3%*	*960*
68.4%	*31.6%*	*17.6%*	*7.8%*	*2.9%*	*3.5%*	*720*
67.7%	*32.3%*	*15.0%*	*9.2%*	*4.8%*	*3.5%*	*315*
–	–	–	–	–	–	*15*
57.8%	*42.2%*	*22.5%*	*12.5%*	*2.8%*	*4.6%*	*505*
66.0%	*34.0%*	*10.6%*	*16.2%*	*5.1%*	*2.5%*	*200*
52.6%	*47.4%*	*22.1%*	*15.1%*	*3.0%*	*7.3%*	*370*
83.2%	*16.8%*	*7.3%*	*5.0%*	*2.2%*	*2.2%*	*180*
82.8%	17.2%	6.5%	5.5%	3.6%	1.7%	705
90.2%	*9.8%*	*0.0%*	*2.4%*	*7.3%*	*0.0%*	*40*
70.4%	*29.6%*	*7.4%*	*3.7%*	*14.8%*	*3.7%*	*25*
–	–	–	–	–	–	*0*
73.9%	*26.1%*	*13.0%*	*4.3%*	*4.3%*	*4.3%*	*25*
67.7%	*32.3%*	*22.6%*	*0.0%*	*3.2%*	*6.5%*	*30*
90.7%	*9.3%*	*4.7%*	*0.0%*	*2.3%*	*2.3%*	*45*
79.6%	*20.4%*	*8.5%*	*6.4%*	*3.2%*	*3.2%*	*95*
84.2%	*15.8%*	*5.4%*	*6.8%*	*2.7%*	*0.9%*	*445*
74.1%	25.9%	16.7%	3.3%	3.7%	2.1%	875
64.4%	35.6%	21.4%	6.5%	4.1%	3.6%	4,740
85.3%	14.7%	5.6%	4.4%	3.3%	1.4%	2,700
77.8%	22.2%	10.9%	7.8%	2.3%	1.3%	32,220
95.8%	4.2%	1.8%	0.4%	1.8%	0.2%	545
77.0%	**23.0%**	**11.4%**	**7.1%**	**2.8%**	**1.8%**	**65,105**
80.9%	**19.1%**	**8.5%**	**6.0%**	**3.2%**	**1.5%**	**96,710**
79.3%	**20.7%**	**9.6%**	**6.4%**	**3.0%**	**1.6%**	**161,815**

Figure 6.17 Students starting research postgraduate courses in the academic year starting in 2015 by STEM marker, subject area, mode of study, domicile, gender and ethnic group – UK

	Mode of study		Domicile			Gender		
STEM subjects	**Full time %**	**Part time %**	**UK %**	**EU %**	**Non EU %**	**Male %**	**Female %**	**Total no.**
Agriculture and related subjects	83.7%	16.3%	53.9%	13.5%	32.6%	43.3%	56.7%	280
Architecture, building and planning	76.4%	23.6%	41.5%	12.4%	46.1%	56.6%	43.4%	615
Biological sciences	88.2%	11.8%	69.1%	13.8%	17.1%	39.9%	60.1%	4,910
Computer science	87.4%	12.6%	41.3%	16.9%	41.8%	72.1%	27.9%	1,595
Engineering and technology (H0-J9)	92.4%	7.6%	38.9%	17.2%	43.9%	75.0%	25.0%	4,460
Engineering disciplines (H0-H9)	92.2%	7.8%	38.0%	17.3%	44.7%	76.1%	23.9%	4,065
(H0) Broadly-based programmes	*–*	*–*	*–*	*–*	*–*	*–*	*–*	*15*
(H1) General engineering	*90.7%*	*9.3%*	*39.4%*	*19.3%*	*41.3%*	*74.6%*	*25.4%*	*1,115*
(H2) Civil engineering	*90.1%*	*9.9%*	*35.4%*	*17.1%*	*47.6%*	*66.5%*	*33.5%*	*475*
(H3) Mechanical engineering	*90.3%*	*9.7%*	*43.3%*	*18.4%*	*38.3%*	*83.6%*	*16.4%*	*640*
(H4) Aerospace engineering	*91.8%*	*8.2%*	*37.6%*	*27.6%*	*34.7%*	*81.8%*	*18.2%*	*170*
(H5) Naval architecture	*95.7%*	*4.3%*	*21.7%*	*13.0%*	*65.2%*	*91.3%*	*8.7%*	*25*
(H6) Electronic and electrical engineering	*95.3%*	*4.7%*	*30.8%*	*12.8%*	*56.4%*	*80.4%*	*19.6%*	*970*
(H7) Production and manufacturing engineering	*86.9%*	*13.1%*	*46.9%*	*16.9%*	*36.3%*	*78.8%*	*21.3%*	*160*
(H8) Chemical, process and energy engineering	*95.4%*	*4.6%*	*43.4%*	*17.4%*	*39.2%*	*67.4%*	*32.6%*	*500*
Technology disciplines (J1-J9)	94.7%	5.3%	48.1%	16.4%	35.5%	63.5%	36.5%	395
(J1) Minerals technology	*100.0%*		*–*	*–*	*–*	*–*	*–*	*5*
(J2) Metallurgy	*93.0%*	*7.0%*	*41.4%*	*20.7%*	*37.9%*	*68.4%*	*31.6%*	*60*
(J3) Ceramics and glass	*100.0%*	*–*	*–*	*–*	*–*	*–*	*–*	*0*
(J4) Polymers and textiles	*100.0%*		*11.5%*		*88.5%*	*42.3%*	*57.7%*	*25*
(J5) Materials technology not otherwise specified	*94.0%*	*6.0%*	*54.3%*	*17.5%*	*28.2%*	*67.4%*	*32.6%*	*235*
(J6) Maritime technology	*–*	*–*	*–*	*–*	*–*	*–*	*–*	*15*
(J7) Biotechnology	*100.0%*		*51.6%*	*25.8%*	*22.6%*	*41.9%*	*58.1%*	*30*
(J9) Others in technology	*96.7%*	*3.3%*	*43.3%*	*3.3%*	*53.3%*	*66.7%*	*33.3%*	*30*
Mathematical sciences	93.7%	6.3%	45.6%	24.2%	30.2%	71.4%	28.6%	955
Medicine and dentistry	78.0%	22.0%	66.6%	10.3%	23.1%	41.5%	58.5%	2,850
Physical sciences	95.4%	4.6%	58.5%	18.2%	23.2%	62.6%	37.4%	4,255
Subjects allied to medicine	78.9%	21.1%	61.4%	12.5%	26.1%	38.8%	61.2%	2,480
Veterinary science	90.8%	9.2%	69.1%	11.3%	19.6%	34.7%	65.3%	100
Total STEM	**87.9%**	**12.1%**	**56.0%**	**15.3%**	**28.6%**	**55.3%**	**44.7%**	**22,500**
Total non STEM	**72.7%**	**27.3%**	**55.9%**	**11.9%**	**32.2%**	**46.7%**	**53.3%**	**13,455**
All subjects	**82.2%**	**17.8%**	**56.0%**	**14.1%**	**29.9%**	**52.1%**	**47.9%**	**35,960**

Source: HESA, student record 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
Ethnicity figures are restricted to UK domiciled entrants. For all other figures, entrants from all domiciles have been included.
To view this table with student numbers, by disability status and ethnicity, and for non STEM subjects, see Figure 6.17 in our Excel resource.

Ethnic group (UK domiciled)		
White %	BME %	Total no.
88.7%	11.3%	150
80.6%	19.4%	250
86.8%	13.2%	3,290
78.1%	21.9%	625
75.9%	24.1%	1,665
75.1%	24.9%	1,485
–	*–*	*10*
77.1%	*22.9%*	*420*
79.3%	*20.7%*	*165*
76.5%	*23.5%*	*265*
80.3%	*19.7%*	*60*
–	*–*	*5*
74.3%	*25.7%*	*285*
71.4%	*28.6%*	*70*
68.1%	*31.9%*	*215*
83.2%	16.8%	185
–	*–*	*0*
73.9%	*26.1%*	*25*
–	*–*	*0*
–	*–*	*5*
82.5%	*17.5%*	*120*
–	*–*	*5*
–	*–*	*15*
–	*–*	*15*
85.2%	14.8%	420
73.9%	26.1%	1,855
88.9%	11.1%	2,410
81.0%	19.0%	1,490
93.8%	6.2%	65
82.5%	**17.5%**	**12,220**
85.0%	**15.0%**	**7,215**
83.4%	**16.6%**	**19,440**

Case study – Perspectives from a current engineering student

Francesca Hand, mechanical and manufacturing engineering, 3rd year student, University of Warwick

"Engineering appeared as a possible career option when I was around 13, having developed an interest in maths, physics and design technology. Obviously, at that age I didn't really know about everything that engineering entailed, but over the years, learning more about it, it became clearer that it was the perfect fit. It had the logical mathematics and the creative design that I loved.

"When it came to my A Level options, I knew that I had to pick maths and physics based on the entry requirements of the universities I was thinking of applying to. I also chose design technology, to maintain the practical hands-on skills, and further maths. This decision was really beneficial to my studies in the first year at university as it meant that I had already seen much of the advanced mathematics that we were covering in the course.

"I decided to apply to general engineering courses at university to gain a broad understanding in all areas of engineering before deciding which one to specialise in. Naturally, there were modules and topics that I enjoyed less than others, but by doing this I discovered which ones I really enjoyed and wanted to take forward. I have now decided to specialise in mechanical and manufacturing engineering for the final 2 years of my masters.

"The learning is so diverse in the course because you experience work in laboratories, have lectures on a variety of different topics and partake in hands-on group projects to apply your knowledge and develop teamwork and leadership skills which are so important if you want to be an employable engineer. In these group projects, you can take on a role to suit you – whether you prefer the theoretical calculations or the practical design and manufacture. As well as the course, university offers so much on the extra-curricular side with academic societies. I have been involved with Engineers Without Borders for the past couple of years, which offers outreach to local schools to excite them about the subject and projects for students to get even more practical experience.

"As for the future, after I graduate, I am still undecided. I have been lucky enough to complete an internship in the renewables sector with Solarcentury and I will be applying again for an internship in a different area for next summer to gain more invaluable experience and hopefully establish what career path to pursue."

Figure 6.18 Changes in the number of engineering and technology first degree qualifiers by select discipline, domicile, gender and ethnic group, from the academic year starting in 2005 to that starting in 2015 – UK

	Non UK domiciled					Female				
	No.	%	Change over 1 year (%)	Change over 5 years (%)	Change over 10 years (%)	No.	%	Change over 1 year (%)	Change over 5 years (%)	Change over 10 years (%)
(H1) General engineering	580	27.4%	13.2% ▲	30.1% ▲	-11.8% ▼	400	19.0%	9.0% ▲	66.1% ▲	-7.3% ▼
(H2) Civil engineering	1,240	31.8%	-6.6% ▼	-1.2% ▼	47.3% ▲	665	17.1%	-4.8% ▼	2.1% ▲	68.4% ▲
(H3) Mechanical engineering	2,025	29.7%	7.2% ▲	36.6% ▲	117.8% ▲	595	8.8%	9.7% ▲	45.8% ▲	120.1% ▲
(H4) Aerospace engineering	545	27.0%	-12.6% ▼	0.0%	106.1% ▲	235	11.6%	11.0% ▲	47.4% ▲	62.6% ▲
(H6) Electronic and electrical engineering	2,130	42.8%	-5.8% ▼	-11.8% ▼	-4.9% ▼	640	12.9%	-2.5% ▼	-4.9% ▼	-9.3% ▼
(H7) Production and manufacturing engineering	195	21.3%	21.6% ▲	-43.8% ▼	-32.2% ▼	190	20.7%	20.3% ▲	10.2% ▲	-3.7% ▼
(H8) Chemical, process, and energy engineering	785	34.7%	12.0% ▲	63.0% ▲	195.0% ▲	620	27.5%	16.8% ▼	71.2% ▲	164.0% ▲
Engineering and technology (H0-J9)	**8,075**	**32.2%**	**1.0%** ▲	**6.1%** ▲	**37.3%** ▲	**3,905**	**15.6%**	**1.9%** ▲	**4.6%** ▲	**23.2%** ▲

Source: HESA, student record 2005/06-2015/16
Ethnicity figures are restricted to UK domiciled qualifiers. For all other qualifiers, qualifiers from all domiciles have been included.
To view this table by domicile, gender and ethnicity for each of the above disciplines and for engineering and technology over time, see **Figure 6.18-16.18g** in our Excel resource.

Figure 6.17 also shows the gender and ethnic profile of research postgraduate entrants. One-quarter (25.0%) of engineering and technology research postgraduate entrants were women, which is the same proportion as for postgraduate taught entrants. This does not mirror the broader gender balance between the two types of postgraduate study, either when all subjects are considered or for STEM subjects. Men made up 52.1% of all research postgraduates but just 39.2% of taught postgraduates, and 55.3% of STEM research postgraduates but 42.7% of taught postgraduates. The proportion of women is, however, higher than at first degree level, again indicating that female engineering and technology graduates are more likely to continue onto postgraduate study than their male peers.

The proportion of engineering and technology entrants who were from a BME background was slightly lower at research postgraduate level than at taught postgraduate level, at 24.1% compared with 29.0%. Nevertheless, this was considerably higher than in STEM and in all subjects combined (17.5% and 16.6% respectively). The proportion of students from a BME background was only higher in two fields: medicine and dentistry (26.1%) and business and administrative studies (31.9%, not shown in **Figure 6.17**).

6.3 – Qualifiers

This section considers the number of students who obtained degree qualifications in engineering in recent years, and were thus eligible to enter the job market and become part of a skilled STEM workforce. Foundation degrees, HNCs and HNDs represent a small and declining proportion of the qualifications obtained in engineering and technology from higher education institutions, mirroring the overall decline in participation in part-time programmes (although provision of HNCs and HNDs in engineering-related subjects by some non-university providers is rising). As a result, more focus is given to first degree and postgraduate degrees, where data is more robust.

First degree undergraduate qualifiers

Over the past 10 years, there has been substantial growth in the number of students in UK higher education qualifying with engineering and technology first degrees. The increase from the academic year starting in 2005 to the year starting in 2015 was 27.0%, with 25,110 students obtaining first degrees compared with 19,775 ten years previously. In terms of year-on-year change, however, 2015 to 2016 was the second consecutive year in which the number of engineering and technology qualifications obtained was lower than the previous year, decreasing by 1.1%. This mirrors a broader trend in the UK student population, with qualifier numbers having fallen in recent years.[6.17]

As **Figure 6.18** shows, 15.6% of the students qualifying with first degree engineering and technology degrees in 2015 to 2016 were women, representing a 1.9% from the previous year and a 23.2% increase over the last 10 years.

In terms of where students came from, nearly one-third were not from the UK in 2015 to 2016, a 1.0% increase on the previous year and a 37.3% increase over the 10 year period. This was largely driven by growth in engineering and technology students from outside the EU. The number of non-EU international qualifiers grew by 52.2% over 10 years, although there was only slight growth between the academic year starting in 2014 and the following year. In contrast, the number of EU first degree qualifiers grew by 2.9% over the last 10 years.

The ethnic composition of students qualifying with first degree engineering and technology degrees has seen quite remarkable change over the last ten years. For the year starting in 2005, 2,350 UK domiciled engineering and technology first degree qualifiers were from a BME background (17.7%). In 2015 to 2016, this figure stood at 4,205, representing a 78.8% increase from ten years previous.

6.17 HESA: Qualifications obtained.

BME (UK domiciled)					All first degree qualifiers			
No.	%	Change over 1 year (%)	Change over 5 years (%)	Change over 10 years (%)	No.	Change over 1 year (%)	Change over 5 years (%)	Change over 10 years (%)
275	18.4%	-1.9% ▼	42.7% ▲	12.6% ▲	2,115	-2.8% ▼	10.3% ▲	-9.5% ▼
770	29.7%	7.0% ▲	38.3% ▲	281.8% ▲	3,890	-9.6% ▼	-4.8% ▼	59.2% ▲
1,020	21.8%	12.1% ▲	75.8% ▲	233.2% ▲	6,810	3.0% ▲	46.8% ▲	90.2% ▲
450	31.6%	12.6% ▲	44.2% ▲	91.9% ▲	2,010	1.9% ▲	30.3% ▲	54.4% ▲
815	29.2%	0.8% ▲	14.5% ▲	0.0%	4,980	-4.2% ▼	-4.1% ▼	-8.9% ▼
95	13.0%	14.8% ▲	6.0% ▲	-28.6% ▼	915	13.2% ▲	-9.5% ▼	-29.3% ▼
545	37.6%	21.4% ▲	92.7% ▲	280.1% ▲	2,255	17.1% ▲	74.9% ▲	186.2% ▲
4,200	**25.2%**	**7.8% ▲**	**38.2% ▲**	**78.8% ▲**	**25,110**	**-1.1% ▼**	**9.6% ▲**	**27.0% ▲**

Looking in more detail by discipline (**Figure 6.19**), electronic and electrical engineering was one of the subjects in which a particularly high proportion of first degree qualifiers were international students (42.8%). This was also the case for naval architecture, metallurgy, maritime technology and biotechnology, although overall qualifier numbers were relatively small in these disciplines.

Given the gender profile of first degree engineering and technology undergraduates, it is perhaps not surprising that the proportion of qualifiers who were women was low, at 15.6%. The proportion of women was even lower among first degree qualifiers in mechanical engineering (8.8%) and minerals technology (5.2%), although overall numbers for the latter were also small.

A quarter of first degree engineering and technology qualifiers in the academic year starting in 2015 were from a BME background, which was lower than the figure for entrants. This could indicate that there has been a rise in BME entrants in recent years or that such students are less likely to complete their courses,[6.18] or both. Qualifiers in disciplines such as civil engineering (29.7%), aerospace engineering (31.6%), electronic and electrical engineering (29.2%), chemical, process and energy engineering (37.6%) and biotechnology (34.8%) were more ethnically diverse than those in taking subjects.

Over the past 10 years, there has been substantial growth in the number of first degree engineering and technology qualifiers. However, 2015 to 2016 was the second consecutive year in which this number was lower than the previous year.

Figure 6.19 Engineering and technology first degree qualifiers by discipline, gender, domicile and ethnicity from the academic year starting in 2005 to the year starting in 2015 – UK

	Domicile			Gender			Ethnicity (UK domiciled only)		
	UK %	EU %	Non EU %	Male %	Female %	Total no.	White %	BME %	Total no.
Engineering disciplines (H0-H9)	67.3%	7.3%	25.4%	85.4%	14.6%	23,185	73.9%	26.1%	15,290
(H0) Broadly-based programmes	–	–	–	–	–	15	–	–	10
(H1) General engineering	*72.6%*	*9.1%*	*18.3%*	*81.0%*	*19.0%*	*2,115*	*81.6%*	*18.4%*	*1,505*
(H2) Civil engineering	*68.2%*	*7.2%*	*24.6%*	*82.9%*	*17.1%*	*3,890*	*70.3%*	*29.7%*	*2,595*
(H3) Mechanical engineering	*70.3%*	*7.1%*	*22.6%*	*91.2%*	*8.8%*	*6,810*	*78.2%*	*21.8%*	*4,685*
(H4) Aerospace engineering	*73.0%*	*7.8%*	*19.2%*	*88.4%*	*11.6%*	*2,010*	*68.4%*	*31.6%*	*1,430*
(H5) Naval architecture	*51.7%*	*32.2%*	*16.1%*	*89.7%*	*10.3%*	*85*	*93.0%*	*7.0%*	*45*
(H6) Electronic and electrical engineering	*57.2%*	*7.3%*	*35.6%*	*87.1%*	*12.9%*	*4,980*	*70.8%*	*29.2%*	*2,795*
(H7) Production and manufacturing engineering	*78.7%*	*5.1%*	*16.2%*	*79.3%*	*20.7%*	*915*	*87.0%*	*13.0%*	*720*
(H8) Chemical, process and energy engineering	*65.3%*	*4.3%*	*30.4%*	*72.5%*	*27.5%*	*2,255*	*62.4%*	*37.6%*	*1,445*
(H9) Others in engineering	*57.5%*	*36.8%*	*5.7%*	*73.6%*	*26.4%*	*105*	*91.7%*	*8.3%*	*60*
Technology disciplines (J1-J9)	74.5%	6.9%	18.6%	73.2%	26.8%	1,930	84.6%	15.4%	1,410
(J1) Minerals technology	*74.1%*	*3.4%*	*22.4%*	*94.8%*	*5.2%*	*60*	*90.7%*	*9.3%*	*45*
(J2) Metallurgy	*38.6%*	*2.3%*	*59.1%*	*77.3%*	*22.7%*	*45*	–	–	*15*
(J3) Ceramics and glass	–	–	–	–	–	*20*	–	–	*20*
(J4) Polymers and textiles	*62.4%*	*3.8%*	*33.8%*	*17.1%*	*82.9%*	*235*	*77.9%*	*22.1%*	*145*
(J5) Materials technology not otherwise specified	*67.5%*	*5.1%*	*27.4%*	*71.9%*	*28.1%*	*315*	*72.1%*	*27.9%*	*205*
(J6) Maritime technology	*56.2%*	*9.8%*	*34.0%*	*83.9%*	*16.1%*	*195*	*95.1%*	*4.9%*	*105*
(J7) Biotechnology	*53.3%*	*15.6%*	*31.1%*	*55.6%*	*44.4%*	*90*	*65.2%*	*34.8%*	*45*
(J9) Others in technology	*86.5%*	*7.3%*	*6.3%*	*86.1%*	*13.9%*	*975*	*88.6%*	*11.4%*	*830*
All engineering and technology (H0-J9)	**67.8%**	**7.3%**	**24.9%**	**84.4%**	**15.6%**	**25,115**	**74.8%**	**25.2%**	**16,700**

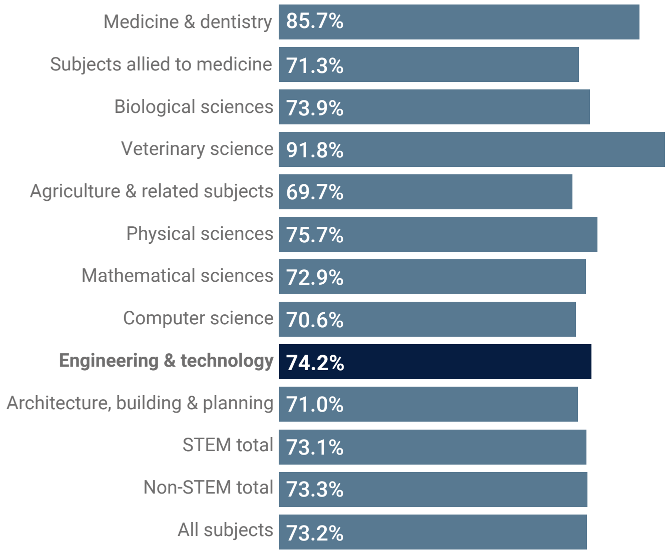
Source: HESA, student record 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
Ethnicity figures are restricted to UK domiciled qualifiers. For all other figures, qualifiers from all domiciles have been included.
To view this table with student numbers, by mode of study, disability status and ethnicity, and figures for non STEM subjects, see Figure 6.19 in our Excel resource.

6.18 ECU. 'Equality in higher education: students statistical report 2016', November 2016.

Degree attainment

The proportion of graduates who attain a first class or upper second class degree is a key benchmark in relation to degree achievement. These grades tend to be used when referring to obtaining 'a good degree'. They have traditionally been an important threshold used by firms during graduate recruitment and are often a requirement for entry to postgraduate study.

Figure 6.20 Proportions of first degree qualifiers achieving a first or upper second class degree by subject area in the academic year starting in 2015 – UK



Source: HESA, student record 2015/16
To view this figure with student numbers and by degree class, see Figure 6.20 in our Excel resource

Figure 6.20 shows that the proportion of students achieving a first or upper second class qualification in their first degree differs by subject area. Almost three-quarters (74.2%) of those qualifying with an engineering and technology degree in the academic year starting in 2015 were awarded a first or upper second class degree, which was slightly higher than for STEM overall (73.1%) and for all subjects combined (73.2%). This result marks an increase from the previous year's figure of 72.7%. The only STEM subjects in which there was a higher proportion of qualifiers obtaining a 'good' degree were medicine and dentistry (85.7%), veterinary science (91.8%) and physical sciences (75.7%).

The rate of engineering and technology qualifiers achieving a first or upper second class varies considerably by different characteristics (Figure 6.21). For example, with regard to domicile, 79.5% of EU qualifiers achieved a 'good' degree, which was higher than UK qualifiers (77.0%) and markedly higher than qualifiers from the rest of the world (65.3%). Full-time engineering and technology first degree qualifiers performed better in respect of the level of degree they attained than part-time qualifiers, with 75.8% of full-time students gaining a first or upper second class compared with 68.0% of part-time students.

Although there are few women first degree undergraduates, those who did qualify for an engineering and technology degree in the academic year starting in 2015 performed better than their male peers. Of the women qualifying, 79.0% achieved a first or upper second class, compared with 73.3% of men.

Conversely, although engineering and technology benefits from a more ethnically diverse student population than most other first degree subjects, white qualifiers outperformed those from a BME background in 2015 to 2016. Four in 5 (80.4%) of white students obtained a 'good' degree compared with 68.5% of BME qualifiers. The degree attainment gap between ethnic minorities and white students has been the subject of much research. This gap has been shown to persist even after accounting for a host of variables that may be expected to have an impact on attainment.[6.19, 6.20, 6.21] However, this difference is lower among engineering and technology first degree qualifiers than across all subjects, at 11.9% compared with 14.9% respectively.

Together, these findings underscore the importance of continuing to make the UK an attractive place for EU students to study and of encouraging women to study engineering and technology. They also suggest that any systemic causes of a BME degree attainment gap within engineering and technology must be addressed if talent is to be most effectively harnessed.

Case study – New Model in Technology and Engineering (NMiTE)

Prof Janusz Kozinski, Founding President and Chief Executive, NMiTE

A new centre for radical engineering and technology education, called the New Model in Technology and Engineering (NMiTE) and backed by £23 million in governmental funding, is scheduled to open in September 2020 in Hereford. At NMiTE, students will have the opportunity to study towards a MEng in 3 years or a BEng in 2 years.

Building on the concept of the humanist engineer developed by founding president Professor Janusz Kozinski, NMiTE will aim to offer an academic programme that will prepare interdisciplinary engineers for a world in which technology is changing who we are.

Central to NMiTE's approach is the belief that everything that isn't created naturally is created by engineers, and that there is an increasing need to develop humanist engineers who create collaboratively, consider the consequences and communicate complexity clearly.

With an emphasis on learning by creating, the centre aims to take a novel approach to both recruitment and teaching. Rather than require prospective students to have taken A level maths and physics, the admissions team will instead aim to assess what the institution sees as the foundations of an engineer's mindset: curiosity, grit and passion. Similarly, the curriculum, which is being developed in collaboration with industry, will replace lectures and exams with developing real world application, innovation, design and creative capabilities.

6.19 DFES. 'Ethnicity and Degree Attainment'. Research Report RW92, August 2011.
6.20 Hefce. 'Differences in degree outcomes: The effect of subject and student characteristics', September 2015.
6.21 ECU. 'Improving the degree attainment of Black and minority ethnic students', February 2011.

Figure 6.21 Engineering and technology first degree qualifiers by degree class, domicile, mode, gender and ethnic group in the academic year starting in 2015 – UK

		First or upper second %	*First %*	*Upper second %*	Lower second %	Third/ Pass %	Total no.
Domicile	UK	77.0%	*34.6%*	*42.4%*	18.5%	4.5%	15,830
	EU	79.5%	*42.2%*	*37.3%*	16.8%	3.7%	1,675
	Non EU	65.3%	*26.8%*	*38.6%*	26.6%	8.0%	6,055
Mode of study	Full time	75.8%	*33.8%*	*42.0%*	20.1%	4.1%	20,885
	Part time	68.0%	*32.8%*	*35.2%*	20.5%	11.5%	2,030
Gender	Male	73.3%	*32.6%*	*40.7%*	21.1%	5.7%	19,865
	Female	79.0%	*36.2%*	*42.8%*	17.2%	3.8%	3,695
Ethnic group (UK domiciled only)	White	80.4%	*38.1%*	*42.4%*	16.2%	3.4%	11,535
	BME total	68.5%	*25.4%*	*43.2%*	24.6%	6.9%	3,985
	Asian	*71.0%*	*28.6%*	*42.4%*	*23.6%*	*5.4%*	*2,140*
	Black	*60.4%*	*17.1%*	*43.3%*	*29.0%*	*10.6%*	*1,005*
	Mixed	*74.7%*	*28.5%*	*46.2%*	*19.3%*	*6.0%*	*485*
	Other	*68.0%*	*24.6%*	*43.3%*	*25.8%*	*6.2%*	*355*
All first degree undergraduate qualifiers (excluding those with unclassified degrees)		**74.2%**	***33.2%***	***41.0%***	**20.5%**	**5.4%**	**23,565**

Source: HESA, student record 2015/16
Ethnicity figures are restricted to UK domiciled qualifiers. For all other figures, qualifiers from all domiciles have been included.
To view this table with student numbers and by disability status, see Figure 6.21 in our Excel resource.

Figure 6.22 Other undergraduate qualifiers by subject area and course aim in the academic year starting in 2015 – UK

	HNC		HND		Foundation degree		All 'other undergraduate' course aims		Total
	No.	%	No.	%	No.	%	No.	%	No.
Agriculture and related subjects	145	11.1%	85	6.5%	955	72.0%	135	10.4%	1,325
Architecture, building and planning	640	62.6%	120	11.9%	145	14.1%	115	11.4%	1,025
Biological sciences	105	4.4%	120	5.1%	1,290	54.8%	840	35.7%	2,355
Computer science	200	14.5%	240	17.6%	660	47.9%	275	20.0%	1,375
Engineering and technology	1,585	37.3%	465	10.9%	1,555	36.6%	640	15.1%	4,240
Mathematical sciences	0	0.0%	0	0.5%	0	0.0%	195	99.5%	200
Medicine and dentistry	0	0.0%	0	0.0%	0	0.0%	65	100.0%	65
Physical sciences	55	8.9%	20	3.4%	220	35.6%	320	52.0%	615
Subjects allied to medicine	95	1.8%	80	1.5%	2,030	38.2%	3,110	58.6%	5,315
Veterinary science	0	–	0	–	0	–	20	–	20
Total STEM	**2,820**	**17.1%**	**1,135**	**6.9%**	**6,845**	**41.4%**	**5,725**	**34.7%**	**16,530**
Total non STEM	**1,095**	**5.1%**	**1,080**	**5.0%**	**8,925**	**41.2%**	**10,570**	**48.8%**	**21,670**
All subjects	**3,915**	**10.3%**	**2,215**	**5.8%**	**15,770**	**41.3%**	**16,295**	**42.7%**	**38,200**

Source: HESA student record 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.

Other undergraduate qualifiers

Figure 6.22 shows the number of students who obtained undergraduate qualifications with a course aim other than a first degree in engineering and technology compared with other subject areas in the academic year starting in 2015. These include foundation degrees and HNC and HND programmes, although, as noted previously, these numbers may not cover the entire spectrum of those studying HNC and HND qualifications from all types of providers.

Altogether, 11.0% of qualifiers who had studied for an 'other undergraduate' degree had done so in engineering and technology. In 2015 to 2016, 40.5% of HNC qualifiers and 21.0% of HND qualifiers had studied engineering and technology. The proportion of foundation degree qualifiers who had studied engineering and technology was more modest, at 9.9%.

Figure 6.23 shows data on other undergraduate qualifiers by domicile, gender, broad ethnic group and select disciplines (due to the relatively small numbers, figures for more detailed ethnic groups are not included). Students qualifying from other undergraduate programmes were markedly less diverse than first degree undergraduate qualifiers, just as entrants were less diverse. Just 14.6% of qualifiers at this level were not from the UK, less than 1 in 10 were women (9.7%) and only 13.8% of those who were UK domiciled were from a BME background. There were, however, some notable exceptions. For example, 1 in 5 of other undergraduate qualifiers who had studied general engineering were from an international background, and a similar proportion of those in production and manufacturing engineering were women.

Figure 6.23 Engineering and technology other undergraduate qualifiers by discipline, domicile, gender and ethnic group in the academic year starting in 2015 – UK

	Domicile			Gender			Ethnicity (UK domiciled only)		
	UK %	EU %	Non EU %	Male %	Female %	Total no.	White %	BME %	Total no.
Engineering disciplines (H0-H9)	87.6%	2.2%	10.2%	90.8%	9.2%	5,035	85.1%	14.9%	4,015
(H0) Broadly-based programmes	*20.3%*	*2.9%*	*76.8%*	*84.1%*	*15.9%*	*70*	–	–	*10*
(H1) General engineering	*79.9%*	*1.4%*	*18.6%*	*87.5%*	*12.5%*	*835*	*85.9%*	*14.1%*	*610*
(H2) Civil engineering	*90.0%*	*3.1%*	*6.9%*	*87.0%*	*13.0%*	*640*	*75.8%*	*24.2%*	*535*
(H3) Mechanical engineering	*90.2%*	*2.6%*	*7.3%*	*93.4%*	*6.6%*	*1,170*	*87.7%*	*12.3%*	*965*
(H4) Aerospace engineering	*92.3%*	*1.5%*	*6.2%*	*94.6%*	*5.4%*	*465*	*80.6%*	*19.4%*	*365*
(H5) Naval architecture	*86.1%*	*5.6%*	*8.3%*	*97.2%*	*2.8%*	*35*	*100.0%*	*0.0%*	*25*
(H6) Electronic and electrical engineering	*92.2%*	*2.1%*	*5.7%*	*92.7%*	*7.3%*	*1,445*	*88.5%*	*11.5%*	*1,215*
(H7) Production and manufacturing engineering	*76.4%*	*1.4%*	*22.2%*	*81.4%*	*18.6%*	*145*	*86.9%*	*13.1%*	*105*
(H8) Chemical, process and energy engineering	*83.2%*	*2.6%*	*14.3%*	*85.2%*	*14.8%*	*195*	*76.0%*	*24.0%*	*155*
Technology disciplines (J1-J9)	73.9%	3.9%	22.2%	87.7%	12.3%	925	93.0%	7.0%	665
(J1) Minerals technology	*100.0%*	*0.0%*	*0.0%*	*90.2%*	*9.8%*	*60*	*98.3%*	*1.7%*	*60*
(J2) Metallurgy	–	–	–	–	–	*5*	–	–	*0*
(J3) Ceramics and glass	–	–	–	–	–	*0*	–	–	*0*
(J4) Polymers and textiles	*63.4%*	*19.5%*	*17.1%*	*63.4%*	*36.6%*	*40*	*87.5%*	*12.5%*	*25*
(J5) Materials technology not otherwise specified	*87.8%*	*4.9%*	*7.3%*	*65.9%*	*34.1%*	*40*	*94.1%*	*5.9%*	*35*
(J6) Maritime technology	*54.7%*	*2.1%*	*43.2%*	*93.9%*	*6.1%*	*430*	*98.3%*	*1.7%*	*230*
(J7) Biotechnology	–	–	–	–	–	*10*	–	–	*5*
(J9) Others in technology	*93.5%*	*4.4%*	*2.1%*	*85.6%*	*14.4%*	*340*	*89.8%*	*10.2%*	*305*
All engineering and technology (H0-J9)	**85.5%**	**2.5%**	**12.1%**	**90.3%**	**9.7%**	**5,960**	**86.2%**	**13.8%**	**4,675**

Source: HESA, student record 2015/16
Ethnicity figures are restricted to the UK domicled qualifiers. For all other figures, qualifiers from all domiciles have been included.
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with student numbers, by mode of study, disability status and ethnicity, and for non STEM subjects, see Figure 6.23 in our Excel resource.

6.18 ECU. 'Equality in higher education: students statistical report 2016', November 2016.

Figure 6.24 Changes in the numbers of engineering and technology taught postgraduate qualifiers by select discipline domicile, gender and ethnic group from the academic year starting in 2005 to that starting in 2015 – UK

	Non UK domiciled					Female				
	No.	%	Change over 1 year (%)	Change over 5 years (%)	Change over 10 years (%)	No.	%	Change over 1 year (%)	Change over 5 years (%)	Change over 10 years (%)
(H1) General engineering	1,045	64.1%	-8.2% ▼	-22.7% ▼	8.3% ▲	400	24.5%	-4.0% ▼	11.0% ▲	71.1% ▲
(H2) Civil engineering	2,245	71.6%	-5.0% ▼	18.5% ▲	117.7% ▲	890	28.3%	-4.6% ▼	0.9% ▲	122.3% ▲
(H3) Mechanical engineering	1,595	75.8%	8.6% ▲	8.8% ▲	176.6% ▲	265	12.5%	9.7% ▲	57.7% ▲	307.4% ▲
(H4) Aerospace engineering	710	75.6%	13.3% ▲	30.6% ▲	332.8% ▲	145	15.4%	15.7% ▲	28.6% ▲	191.9% ▲
(H6) Electronic and electrical engineering	2,620	85.7%	-2.9% ▼	-29.3% ▼	4.1% ▲	675	22.1%	0.1% ▲	13.4% ▲	17.0% ▲
(H7) Production and manufacturing engineering	930	81.7%	5.7% ▲	-6.2% ▼	27.4% ▲	345	30.5%	18.7% ▲	33.4% ▲	53.5% ▲
(H8) Chemical, process, and energy engineering	930	72.7%	-7.0% ▼	1.8% ▲	158.1% ▲	380	29.6%	6.3% ▲	32.8% ▲	164.2% ▲
Engineering and technology (H0-J9)	**11,465**	**73.9%**	**-0.2% ▼**	**-4.3% ▼**	**63.9% ▲**	**3,825**	**24.6%**	**1.3% ▲**	**14.6% ▲**	**79.4% ▲**

Source: HESA, student record 2015/16
Ethnicity figures are restricted to the UK domicled qualifiers. For all other figures, qualifiers from all domiciles have been included.
To view this table by domicile, gender and ethnicity for each of the above disciplines and for engineering and technology over time, see Figure 6.24-6.24g in our Excel resource.

Taught postgraduate qualifiers

Figure 6.24 illustrates the strong growth in taught postgraduate participation in engineering and technology over the last ten year period. In the academic year starting in 2005, the number of engineering and technology qualifiers at postgraduate level stood at 10,455; ten years later, it had increased by 48.5%, to 15,520.

While women remain underrepresented, the proportion of female engineering and technology taught postgraduate qualifiers has risen in this period. Just under a quarter were women in the academic year starting in 2015 (3,825 out of 15,520), representing a 1.3% increase from the previous year and a 79.4% increase over the last ten years. Taught postgraduate qualifiers have also grown more ethnically diverse: for the academic year starting 2015, 1,085 of the 3,725 UK domiciled engineering and technology qualifiers at this level were from a BME background (29.2%). This number represents a 111.3% increase from ten years previous, when the figure stood at 515.

Nearly three quarters of the 11,465 engineering and technology taught postgraduate qualifiers were not from the UK in 2015 to 2016 (73.9%). While this marks a slight percentage decrease on the previous year (-0.2%), it represents a 63.9% increase from the academic year starting in 2005. This was largely driven by a rise in international students from outside the EU, with the number of non-EU international qualifiers growing by 74.3% over the 10 year period. Growth in the number of EU first degree qualifiers was more modest in comparison, rising 32.5% relative to levels ten years ago.

This highly international profile is reflected in many engineering disciplines, in particular electronic and electrical engineering and production and manufacturing engineering, for which the proportion of international students exceeded 80% (85.6% and 81.7% respectively, Figure 6.25). This was also the case for several other disciplines, although the qualifier numbers in many of these were very small.

Figure 6.25 shows that the gender profile of students qualifying in postgraduate taught courses also varied by discipline. The majority of those qualifying in biotechnology were women (50.6%), for example. A quarter or more of postgraduate taught qualifiers in some other disciplines were women, such as general engineering (24.5%), civil engineering (28.4%), production and manufacturing engineering (30.5%) and chemical, process and energy engineering (29.6%). However, far fewer women qualified in mechanical engineering (12.5%) and naval architecture (11.4%), although only 160 in total studied the latter at taught postgraduate level.

Similar variations were seen in the proportion of BME students qualifying in taught postgraduate engineering and technology disciplines. Overall, 29.2% were BME, which is much higher than in other subject areas, with 45.9% of qualifiers in electronic and electrical engineering from a BME background, for example. In contrast, technology disciplines as a whole tended to have much lower ethnic diversity, with just 12.6% of qualifiers from a BME background.

BME (UK domiciled)					All first degree qualifiers			
No.	%	Change over 1 year (%)	Change over 5 years (%)	Change over 10 years (%)	No.	Change over 1 year (%)	Change over 5 years (%)	Change over 10 years (%)
110	21.1%	-4.3% ▼	3.3% ▲	65.2% ▲	1,625	-1.7% ▼	-16.7% ▼	1.3% ▲
245	30.7%	20.3% ▲	-19.5% ▼	208.7% ▲	3,140	-3.7% ▼	-3.3% ▼	99.6% ▲
165	33.6%	1.9% ▲	34.8% ▲	454.6% ▲	2,105	10.5% ▲	9.2% ▲	159.9% ▲
65	29.7%	26.0% ▲	24.8% ▲	263.9% ▲	935	18.3% ▲	28.4% ▲	200.1% ▲
175	45.9%	10.1% ▲	-28.1% ▼	22.7% ▲	3,055	-2.1% ▼	-28.6% ▼	-2.1% ▼
70	36.1%	1.3% ▲	-31.1% ▼	35.0% ▲	1,135	6.5% ▲	-12.0% ▼	14.2% ▲
130	39.7%	-6.8% ▼	3.4% ▲	227.5% ▲	1,280	-4.1% ▼	6.5% ▲	137.0% ▲
1,085	**29.2%**	**5.4% ▲**	**-8.5% ▼**	**111.3% ▲**	**15,520**	**1.5% ▲**	**-7.4% ▼**	**48.5% ▲**

Figure 6.25 Taught postgraduate qualifiers by discipline, domicile, gender and ethnic group in the academic year starting in 2015 – UK

	Domicile			Gender			Ethnicity (UK domiciled only)		
	UK %	EU %	Non EU %	Male %	Female %	Total no.	White %	BME %	Total no.
Engineering disciplines (H0-H9)	24.7%	15.0%	60.2%	76.9%	23.1%	13,935	67.9%	32.1%	3,165
(H0) Broadly-based programmes	*–*	*–*	*–*	*–*	*–*	*5*	*–*	*–*	*0*
(H1) General engineering	*35.9%*	*16.5%*	*47.6%*	*75.5%*	*24.5%*	*1,625*	*78.9%*	*21.1%*	*530*
(H2) Civil engineering	*28.4%*	*14.1%*	*57.5%*	*71.6%*	*28.4%*	*3,140*	*69.4%*	*30.6%*	*795*
(H3) Mechanical engineering	*24.2%*	*18.4%*	*57.4%*	*87.5%*	*12.5%*	*2,105*	*66.3%*	*33.7%*	*485*
(H4) Aerospace engineering	*24.4%*	*33.8%*	*41.7%*	*84.5%*	*15.5%*	*935*	*70.1%*	*29.9%*	*220*
(H5) Naval architecture	*20.9%*	*30.4%*	*48.7%*	*88.6%*	*11.4%*	*160*	*65.6%*	*34.4%*	*30*
(H6) Electronic and electrical engineering	*14.3%*	*7.4%*	*78.2%*	*77.9%*	*22.1%*	*3,055*	*54.1%*	*45.9%*	*380*
(H7) Production and manufacturing engineering	*18.3%*	*14.3%*	*67.4%*	*69.5%*	*30.5%*	*1135*	*63.8%*	*36.2%*	*200*
(H8) Chemical, process and energy engineering	*27.3%*	*12.1%*	*60.5%*	*70.4%*	*29.6%*	*1,280*	*60.3%*	*39.7%*	*325*
(H9) Others in engineering	*41.1%*	*17.6%*	*41.3%*	*79.7%*	*20.3%*	*490*	*76.5%*	*23.5%*	*195*
Technology disciplines (J1-J9)	38.4%	13.2%	48.4%	61.6%	38.4%	1,590	87.4%	12.6%	565
(J1) Minerals technology	*77.4%*	*11.3%*	*11.3%*	*79.6%*	*20.4%*	*55*	*97.6%*	*2.4%*	*40*
(J2) Metallurgy	*24.7%*	*9.1%*	*66.2%*	*81.8%*	*18.2%*	*75*	*–*	*–*	*15*
(J3) Ceramics and glass	*–*	*–*	*–*	*–*	*–*	*20*	*–*	*–*	*0*
(J4) Polymers and textiles	*7.3%*	*6.6%*	*86.1%*	*39.4%*	*60.6%*	*135*	*–*	*–*	*10*
(J5) Materials technology not otherwise specified	*16.7%*	*7.2%*	*76.0%*	*60.6%*	*39.4%*	*220*	*58.1%*	*41.9%*	*30*
(J6) Maritime technology	*25.6%*	*27.2%*	*47.2%*	*78.5%*	*21.5%*	*195*	*93.9%*	*6.1%*	*50*
(J7) Biotechnology	*32.9%*	*11.2%*	*55.9%*	*49.4%*	*50.6%*	*350*	*80.0%*	*20.0%*	*105*
(J9) Others in technology	*63.1%*	*14.9%*	*22.0%*	*65.3%*	*34.7%*	*535*	*90.4%*	*9.6%*	*315*
All engineering and technology (H0-J9)	**26.1%**	**14.8%**	**59.0%**	**75.3%**	**24.7%**	**15,520**	**70.8%**	**29.2%**	**3,725**

Source: HESA, student record 2015/16
Ethnicity figures are restricted to UK domiciled qualifiers. For all other figures, qualifiers from all domiciles have been included.
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with student numbers, by mode of study, disability status and ethnicity, and for non STEM subjects, see Figure 6.25 in our Excel resource.

Research postgraduate qualifiers

In the academic year starting in 2015, 1 in 8 (12.8%) of the 27,375 research postgraduates who qualified did so in an engineering and technology subject. Among those who obtained a doctorate, this proportion was even higher, at 14.0%.

Because the numbers of research postgraduate qualifiers in each discipline are relatively small, they can show large proportional changes year-on year, and hence time series data is not presented here, though they can be found in our Excel resource (see 6.24-6.24g series). Similarly, only figures for the larger disciplines are shown.

Figure 6.26 shows that there was a different balance in the disciplines studied by research postgraduate qualifiers who obtained a doctorate or other research qualification compared with undergraduates and taught postgraduates. For example, 22.9% of engineering and technology related doctorates were in electronic and electrical engineering and 20.6% were in general engineering. Among those who obtained an engineering and technology related postgraduate research qualification other than a doctorate, 3 in 10 (30.4%) had done so in general engineering and 17.9% in electronic and electrical engineering.

Figure 6.27 provides a breakdown of engineering and technology research postgraduate qualifiers by discipline, domicile, gender and ethnic group. The proportion of research postgraduate engineering and technology qualifications obtained by international students in 2015 to 16 was high, at over 60.3%. The figure for electrical and electronic engineering was even higher at 67.8%.

The percentage of research postgraduate qualifications achieved by women was higher than the proportion at first degree level (24.1% compared with 15.6%), which is similar to what was seen among taught postgraduate qualifiers.

Figure 6.26 Engineering and technology research postgraduate qualifiers by qualification type and discipline in the academic year starting in 2015 – UK

	Doctorate		Other postgraduate research qualification		Total research postgraduate qualifiers	
	No	%	No	%	No	%
Engineering and technology (H0-J9)	3,235	14.0%*	280	6.5%*	3,515	12.8%*
Engineering disciplines (H0-H9)	2,870	88.7%	245	87.5%	3,115	88.6%
(H0) Broadly-based programmes within engineering and technology	–	–	0	–	–	0
(H1) General engineering	665	20.6%	85	30.4%	745	21.2%
(H2) Civil engineering	375	11.6%	30	10.7%	410	11.7%
(H3) Mechanical engineering	495	15.3%	25	8.9%	520	14.8%
(H4) Aerospace engineering	140	4.3%	30	10.7%	165	4.7%
(H5) Naval architecture	10	0.3%	0	0.0%	10	0.3%
(H6) Electronic and electrical engineering	740	22.9%	50	17.9%	790	22.5%
(H7) Production and manufacturing engineering	90	2.8%	10	3.6%	95	2.7%
(H8) Chemical, process and energy engineering	360	11.1%	15	5.4%	375	10.7%
(H9) Others in engineering	5	0.2%	0	0.0%	5	0.1%
Technology disciplines (J1-J9)	365	11.3%	40	14.3%	405	11.5%
(J1) Minerals technology	5	0.2%	0	0.0%	5	0.1%
(J2) Metallurgy	85	2.6%	5	1.8%	95	2.7%
(J3) Ceramics and glass	5	0.2%	0	0.0%	5	0.1%
(J4) Polymers and textiles	15	0.5%	5	1.8%	20	0.6%
(J5) Materials technology not otherwise specified	180	5.6%	15	5.4%	195	5.5%
(J6) Maritime technology	20	0.6%	0	0.0%	20	0.6%
(J7) Biotechnology	25	0.8%	10	3.6%	30	0.9%
(J9) Others in technology	30	0.9%	5	1.8%	35	1.0%
Total STEM	**15,090**	**65.5%***	**2,505**	**57.9%***	**17,595**	**64.3%***
Total non STEM	**7,955**	**34.5%***	**1,825**	**42.1%***	**9,780**	**35.7%***
All subjects	**23,045**	**100.0%***	**4,330**	**100.0%***	**27,375**	**100.0%***

Source: HESA, student record 2015/16
* indicates the percentage calculated from the total across all subject areas. All other percentages relate to the proportion within engineering and technology.
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.

However, the proportion of women varied widely by discipline. Over one-third of those in technology disciplines were women (34.8%) and there were a similar proportion of women in chemical, process and energy engineering. However, women accounted for less than one in 5 of postgraduate qualifiers in mechanical (19.6%) and aerospace engineering (14.5%).

The ethnic profile of research postgraduate qualifiers tended to be more consistent across disciplines. The proportion from a white background ranged from 81.2% in technology disciplines to 72.5% in electronic and electrical engineering. The notable exception was production and manufacturing engineering, where the majority of research postgraduate qualifiers were from a BME background, although overall numbers in this discipline were relatively low.

Overall, 60.3% of engineering and technology qualifiers at research postgraduate level were from an international background. This proportion was particularly high among those studying electrical and electronic engineering (67.8%).

Figure 6.27 Engineering and technology research postgraduate qualifiers by discipline, domicile, gender and ethnic group in the academic year starting in 2015 – UK

	Domicile			Gender			Ethnicity (UK domicile only)		
	UK %	EU %	Non EU %	Male %	Female %	Total no.	White %	BME %	Total no.
Engineering disciplines (H0-H9)	38.6%	14.9%	46.5%	77.3%	22.7%	3,115	75.7%	24.3%	1,055
(H0) Broadly-based programmes within engineering & technology	–	–	–	–	–	*0*	–	–	*0*
(H1) General engineering	*42.2%*	*15.5%*	*42.2%*	*77.6%*	*22.4%*	*745*	*80.8%*	*19.2%*	*290*
(H2) Civil engineering	*42.8%*	*16.1%*	*41.1%*	*72.4%*	*27.6%*	*410*	*74.8%*	*25.2%*	*150*
(H3) Mechanical engineering	*38.8%*	*15.4%*	*45.8%*	*80.4%*	*19.6%*	*520*	*75.7%*	*24.3%*	*170*
(H4) Aerospace engineering	*36.1%*	*25.9%*	*38.0%*	*85.5%*	*14.5%*	*165*	*74.1%*	*25.9%*	*60*
(H5) Naval architecture	–	–	–	–	–	*10*	–	–	*0*
(H6) Electronic & electrical engineering	*32.2%*	*12.0%*	*55.8%*	*81.9%*	*18.1%*	*790*	*72.5%*	*27.5%*	*220*
(H7) Production & manufacturing engineering	*37.5%*	*11.5%*	*51.0%*	*74.0%*	*26.0%*	*95*	*48.4%*	*51.6%*	*30*
(H8) Chemical, process & energy engineering	*41.2%*	*13.8%*	*44.9%*	*65.9%*	*34.1%*	*375*	*78.0%*	*22.0%*	*130*
(H9) Others in engineering	–	–	–	–	–	*5*	–	–	*0*
Technology disciplines (J1-J9)	49.0%	11.2%	39.8%	65.2%	34.8%	400	81.2%	18.8%	170
(J1) Minerals technology	–	–	–	–	–	*5*	–	–	*5*
(J2) Metallurgy	*48.4%*	*9.7%*	*41.9%*	*67.4%*	*32.6%*	*90*	*81.4%*	*18.6%*	*45*
(J3) Ceramics & glass	–	–	–	–	–	*5*	–	–	*0*
(J4) Polymers & textiles	–	–	–	–	–	*20*	–	–	*5*
(J5) Materials technology not otherwise specified	*50.5%*	*11.3%*	*38.1%*	*68.2%*	*31.8%*	*195*	*77.9%*	*22.1%*	*75*
(J6) Maritime technology	–	–	–	–	–	*20*	–	–	*10*
(J7) Biotechnology	*28.1%*	*18.8%*	*53.1%*	*38.7%*	*61.3%*	*30*	–	–	*5*
(J9) Others in technology	*68.6%*	*8.6%*	*22.9%*	*68.6%*	*31.4%*	*35*	–	–	*20*
All engineering and technology (H0-J9)	**39.7%**	**14.5%**	**45.8%**	**75.9%**	**24.1%**	**3,515**	**76.4%**	**23.6%**	**1,225**

Source: HESA, student record 2015/16
Ethnicity figures are restricted to UK domiciled qualifiers. For all other figures, entrants from all domiciles have been included.
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with student numbers, by mode of study, disability status and ethnicity, and for non STEM subjects, see Figure 6.27 in our Excel resource.

Equality, diversity, engineering and higher education

Equality and diversity is vitally important for any organisation in the modern world. There is a strong moral and legal case for industry to take equality and diversity seriously – but it also makes very good business sense. Repeated academic studies[6.22] have demonstrated that significant external and internal benefits accrue to employers with diverse workforces. For example, employees from different cultures can help businesses better understand international markets, which enables expansion, while a visible commitment to diversity sends an important message to potential customers who are themselves diverse and want to work with those who understand them. Meanwhile, internal benefits can arise as employers draw on the widest possible talent in recruitment – both by making the right decisions and because they are able to attract more applications – and the diversity of perspective which a diverse workforce provides helps businesses make better decisions.

For these and other reasons, the Equality Challenge Unit (ECU) works to help universities and other higher education providers ensure that they meet their own obligations and ambitions in relation to equality and diversity, from increasing the number of professors and other senior academic staff from different backgrounds to developing the best strategies for recruiting a diverse cohort of students to particular disciplines.

This, in turn, has benefits beyond higher education: for example, we know that role models are important in encouraging women to go into engineering and other STEM subjects[6.23], and having prominent female academics in engineering – such as Professor Dame Ann Dowling at Oxford and Professor Karen Holford at Cardiff – helps to attract women to study the discipline and from there go on to take up roles in industry, teaching and international development.

Equality Challenge Unit

David Ruebain,
Chief Executive,
Equality Challenge Unit

It is a challenging environment for higher education in the UK. There remains a risk that the sheer pace of change will detract from the work required to address more deep-rooted equality and diversity issues affecting staff or students.

It is a challenging environment for higher education in the UK: there are number of changes facing universities, each with their own equality and diversity considerations. The Higher Education and Research Act 2017 creates a new regulator in England, the Office for Students, and gives legislative underpinning to the Teaching Excellence Framework (TEF). The aim of the reforms is to ensure a greater focus on students as consumers and to give those students more information about the 'quality' of their courses. However, there is intense debate about: the usefulness of the current metrics underpinning the TEF as measurements of teaching quality; if and how the TEF can be extended to individual subjects, including engineering; and – most importantly for equality and diversity – whether the TEF may provide perverse incentives for institutions to avoid recruiting those students who may face additional barriers to success. For example, engineering has strong employment outcomes and higher graduate salaries than many other subjects, both of which mean an improved TEF score, but BME engineering graduates are less likely to find full-time employment after graduation compared with their white peers, even after controlling for other factors.[6.24] The aim here must be to reduce this disparity rather than see fewer BME students take up engineering courses.

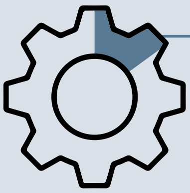
Significant changes face institutions in other parts of the UK. In Wales, the Diamond and Hazelkorn reviews will change the funding of higher education for institutions and students, as well as reorganise many key agencies. In Scotland, fair access is a key concern despite the absence of fees, with a new fair access commissioner placing significant pressure on institutions. And in Northern Ireland, budget cuts have hit universities hard. These present both opportunities and threats to equality and diversity outcomes.

In addition, as with almost every other part of British society, higher education will be affected by Brexit. The final agreement with the EU is currently significantly uncertain, but for universities there is a very real possibility they will be less able to recruit EU students and attract EU research funding. This would not only reduce income at a time when many face multiple pressures, especially in high-cost subjects, but also reduces the diversity of the student intake and potentially EU

6.22 BIS. 'The business case for equality and diversity', January 2013.
6.23 Ofsted. Girls' career aspirations, April 2011.

graduates who would choose to work in the UK. The debate on immigration and the rhetoric around Brexit may also impact on the views of those international students considering the UK, and institutions will need to work hard to ensure that their commitment to equality and diversity is clear and that the UK remains a destination of choice.

Moreover, there remains an additional risk that the sheer pace of change will detract from the work required to address more deep-rooted equality and diversity issues affecting staff or students. Engineering has its specific challenges[6.25]: there is a long-standing and very significant gender imbalance in student recruitment, and only 16% of engineering and technology undergraduates are women. Yet other inequalities also exist: whereas 80% of white engineering and technology graduates received a first or upper second class degree, only 69% of BME graduates did so. And only 9% of engineering and technology students declared a disability, compared with 11% of all students.



Only 16% of engineering and technology undergraduates are women

80% of white engineering and technology graduates obtained a first or upper second class degree compared with

69% of BME engineering and technology graduates

9% of engineering and technology students declared a disability, compared with

11% of all students

Student inequalities lead, in turn, to staff inequalities. Just as there is gender imbalance among students, so there is among staff, with, for example, just 14% of electrical, electronic and computer engineering academics who are female.

Women engineering academics reported they were less likely to feel that they were encouraged in their careers than men, and more reported barriers to training and development.

Student inequalities lead, in turn, to staff inequalities. To take one example, just as there is a gender imbalance among students, so there is among staff, with the proportion of women academic staff ranging from 14% in electrical, electronic and computer engineering to 27% in chemical engineering.[6.26] In ECU's ASSET report on gender equality in STEM subjects[6.27], women engineering academics reported they were less likely to feel that they were encouraged in their careers than men, and more reported barriers to training and development.

However, engineering departments across the UK recognise the need for action. Many are participating in ECU's Athena SWAN gender equality charter, while others are developing innovative projects that will have impact beyond higher education. Edinburgh Napier University and Equate Scotland have developed a 'Confident Diversity' module for the third year of Napier's Engineering Management course, to help ensure that future managers and leaders in engineering understand and champion equality and diversity. As part of ECU's work to diversify recruitment, Oxford Brookes University is looking at increasing the representation of women on its mechanical engineering programmes, researching why the under-representation comes about and developing positive action strategies to develop those barriers. To take just one of the many examples from Athena SWAN award holders, the University of Sheffield's Department of Electronic and Electrical Engineering has put in place a women's adviser to help their female staff discuss career development.

There remains, of course, much work to do and ECU will continue to support institutions and departments in tackling equality and diversity issues. Projects like those mentioned above show that with the right analysis and actions, it is possible to make a positive impact. Employers in the engineering sector have a very significant role to play in promoting equality and diversity, working with universities and on their own. This can include providing visible role models for diverse groups to encourage entry to engineering, or through championing equality and diversity so that all individuals feel confident that they will thrive in an engineering career.

Addressing all of these challenges won't be easy, but if universities and employers can get this right, the benefits will be enormous for industry and society alike.

6.24 RaEng. 'Employment outcomes of engineering graduates: key factors and diversity characteristics', November 2016.
6.25 ECU. 'Equality in higher education: students statistical reports 2014 and 2015', 2014 & 2015.
6.26 ECU. 'Equality in higher education: students statistical reports 2014 and 2015', 2014 & 2015.
6.27 ECU. Asset 2016, April 2017.

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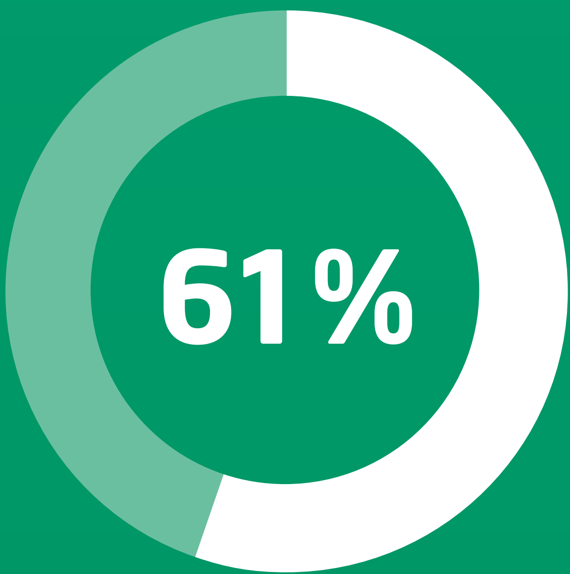
The engineering workforce

Despite employer concerns about work readiness, graduate employment prospects are strong.



of UK domiciled engineering and technology students who found employment six months after graduating were in an engineering occupation

There is robust demand for engineering skills – and a marked skills shortage.

124K

graduates and technicians are needed per year to fulfill demand for core engineering jobs

7 - The composition of the engineering workforce

19% of the UK workforce worked in engineering enterprises in 2016

12% of those working in engineering occupations were women

Key points

Population demographics

By mid-2016, UK population was the highest it has ever been, at 65.6 million. Over the next 25 years, it is projected to increase even more. However, although the UK population is growing, it is also ageing. With lower birth rates and higher life expectancy, the proportion of those of a working age is shrinking whilst those of a pensionable age is increasing.

The UK workforce

Some 32 million people were employed in the UK in 2017, reflecting an employment rate of 74.9%. This is the highest rate since comparable records began in 1971. Of these, 23.5 million people were working full time (364,000 more than for a year earlier) and 8.5 million were working part time (125,000 more than a year earlier). Non UK nationals accounted for 11.1% of the 32 million in employment – nearly two thirds of whom were from the EU.

Rates of both employment and unemployment varied by nation and region. Employment amongst those aged 16 to 64 years was highest in the South West (79.2%), closely followed by the South East (78.9%). These two regions also had the lowest unemployment rates (3.5% and 3.4%, respectively). In contrast, employment and unemployment rates among those aged 16 to 64 stood at 68.7% and 5.3%, respectively, in Northern Ireland. Unemployment was also relatively high in the North East (6.0%) and the West Midlands (5.9%).

Employment in the engineering sector

Workers within the engineering sector – including in engineering and non-engineering occupations – accounted for 18.9% of all employees in 2016, a decrease of 2.1 percentage points since 2009. However, it is clear that some engineering industries are expanding while others are in decline. The number of workers in engineering-related industries within the information and communications sector, for example, has increased by 9.4% relative to 2009 levels. In contrast, employment in manufacturing has shrunk by nearly 10.9%, though it continues to account for 42.3% of employment in engineering enterprises.

It is evident that the gender profile of those working in the engineering sector does not reflect that of the overall working population. While women comprised 46.9% of the overall UK workforce, for example, they only made up 20.5% of those working in the engineering sector.

Likewise, the proportion of workers from ethnic minority groups in the engineering sector (8.1%) was below the proportion in non-engineering sectors (12.7%) and the UK workforce (12.0%).

Also apparent is the key role EU nationals play in the engineering sectors skills supply. Data from the Labour Force Survey shows that 7.7% of workers in the EngineeringUK sectoral footprint in 2016 were EU nationals, compared with 6.1% in non engineering sectors. In the first quarter of 2017, EU nationals made up a higher share of workers in key engineering-related industries, including manufacturing (11.5%), construction (8.7%) and professional, scientific and technical activities (8.1%) than across the economy overall (7.3%).

While the engineering sector is dominated by small employers, the majority of employees in 2016 worked for larger enterprises. Nevertheless, since 2009, there has been a growing trend toward employment in smaller enterprises. This is evident in most engineering-related industries other than manufacturing.

Employment in engineering occupations across sectors

It is apparent that a significant proportion of those working in engineering occupations do so outside of the sectoral footprint – that is, engineering industries. There were 1.7 million workers in engineering-related roles in other sectors in 2016, constituting 28.4% of the total workforce in engineering occupations.

Overall, gender diversity is even lower in the occupational footprint–that is, workers in engineering occupations accross all sectors. Only 12.0% of workers in the EngineeringUK occupational footprint were female in 2016, compared with 20.5% in the sectoral footprint. Strikingly, proportionally more women (18.6%) were in an engineering role outside the engineering sector than within (9.3%).

The underrepresentation of workers from ethnic minorities in engineering occupations is also as significant an issue as among workers in the engineering sector, with only 8.3% of workers from ethnic minority backgrounds.

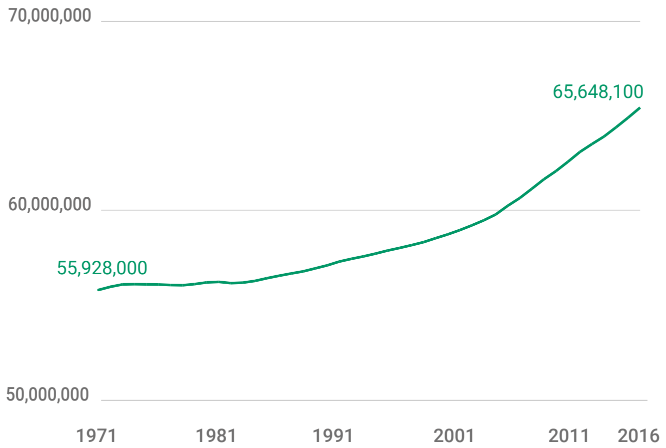
Employer action to increase diversity in engineering is critical. Yet in 2017 only 15.0% of employers surveyed by IET reported making particular efforts to attract and retain women, and just 9% indicated they run specific initiatives to attract or recruit more BME or LGBT employees.

7.1 – Population demographics

Two broad trends are evident in demographic analysis of the UK population. Firstly, the UK population is growing: in mid-2016, it stood at 65.6 million, its largest ever (**Figure 7.1**).[7.1] This number includes long-term international migrants (people who change their usual country of residence for 12 months or more) but does not account for short-term migrants.

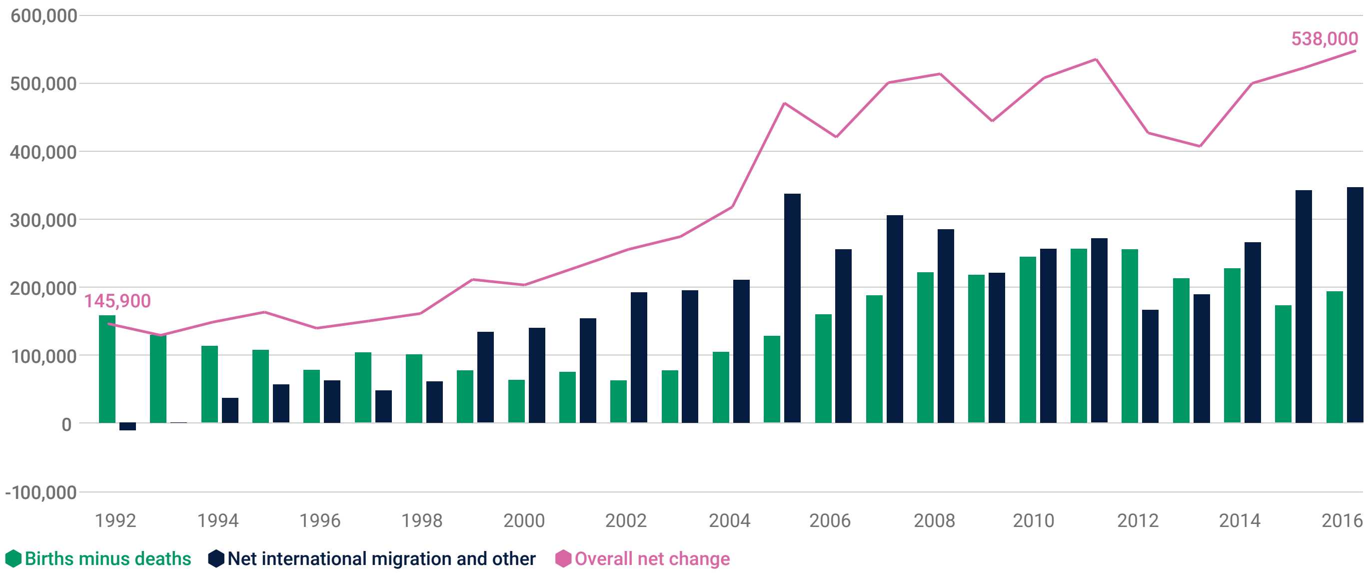
Net international migration has continued to be the main driver for this population increase (**Figure 7.2**). The annual growth in the UK population observed in mid-2016 reflected increases of 193,000 people (35.8% of the total increase) through natural growth and 336,000 through net internal migration (62.4% of the total increase). Other changes accounted for the remaining 1.8%.

Figure 7.1 Mid-year population estimates from 1971 to 2016 – UK



Source: ONS 2017
To view this chart with numbers from 1971 to 2016, see **Figure 7.1** in our Excel resource.

Figure 7.2 Population change from 1992 to 2016 – UK



Source: ONS, National Records of Scotland, Northern Ireland Statistics and Research Agency 2017
To view this chart with numbers from 1992 to 2016, see **Figure 7.2** in our Excel resource.

Notably, this growth is not taking place uniformly across the UK. At 0.9%, annual growth was highest in England, where the population exceeded 55 million for the first time in 2016 (**Figure 7.3**). In comparison, the annual population growth in Scotland was 0.6%, Northern Ireland 0.6% and Wales 0.5%.

Secondly, in addition to growing, the UK population is ageing (**Figure 7.4**). In 2016, 63.1% of people were aged 16 to 64, with the remainder split fairly evenly between the 0 to 15 and age 65 and over age groups (18.0% and 18.9% respectively).[7.2] It's worth noting that the proportion of children in the UK population has declined, from over 24.5% in 1976 to 18.9% in 2016. Further discussion about population trends, with a focus on the likely future numbers of young people, can be found in **Chapter 3**.

The shrinking proportions of people of working age, alongside an increase in those of a pensionable age, has important implications for the future engineering skills supply, as well as more broadly for society.

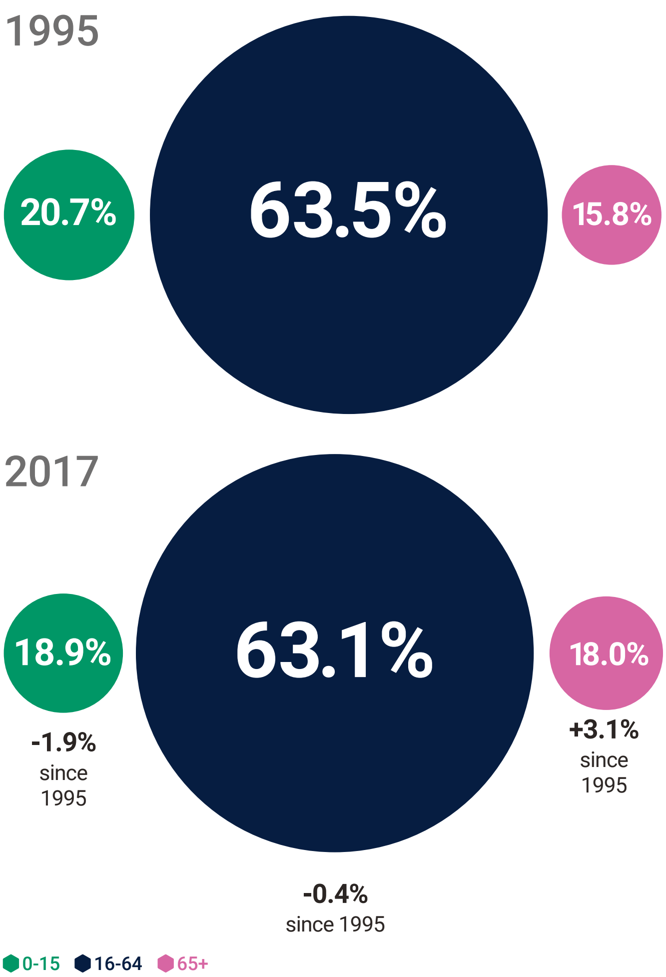
7.1 ONS. 'Population estimates for UK, England and Wales, Scotland and Northern Ireland: mid-2016', June 2017.
7.2 ONS. 'Overview of the UK population: July 2017', July 2017.

Figure 7.3 Population growth and change by nation from mid-2015 to mid-2016 – UK

	Population 2016	Proportion of UK population	Change over 1 year (n)	Change over 1 year (%)	Change over 10 years (%)
England	55,268,100	84.2%	481,800	0.9% ▲	8.4% ▲
Wales	3,113,200	4.7%	14,100	0.5% ▲	4.3% ▲
Scotland	5,404,700	8.2%	31,700	0.6% ▲	5.3% ▲
Northern Ireland	1,862,100	2.8%	10,500	0.6% ▲	6.8% ▲
UK	**65,648,100**	**100.0%**	**538,100**	**0.8% ▲**	**7.9% ▲**

Source: ONS, National Records of Scotland, Northern Ireland Statistics and Research Agency 2017

Figure 7.4 Age profile of the population from 1995 to 2017 – UK



Source: ONS, Overview of the UK population: March 2017, July 2017

This picture of a growing, aging population looks set to continue. By 2039, more than 74 million people are projected to live in the UK (**Figure 7.5**). Assumed net migration is expected to account for 51% of this growth, with the remaining 49% coming from national increase (more births than deaths).[7.3] Lower birth rates and higher life expectancy will fuel the aging of the population: the average (median) age is predicted to rising from 40 to 42.9 by mid-2039 and the proportion of people aged 65 and over will increase to a quarter of the total population by 2046.

The shrinking proportions of people of a working age, alongside an increase in those of a pensionable age, has important implications for the future engineering skills supply, as well as more broadly for society (such as future provision of health/social care services and pensions).

Figure 7.5 Population projections (millions) by nation from 2014 to 2039 – UK

	2014	2019	2024	2029	2034	2039
England	54.3	56.5	58.4	60.2	61.8	63.3
Wales	3.1	3.1	3.2	3.2	3.3	3.3
Scotland	5.3	5.4	5.5	5.6	5.7	5.7
Northern Ireland	1.8	1.9	1.9	2.0	2.0	2.0
UK	**64.6**	**66.9**	**69.0**	**71.0**	**72.7**	**74.3**

Source: ONS, 2017

It is of course important to note that population projections have limitations: they are not forecasts and do not attempt to predict the impact that future government policies, changing economic circumstances or other factors might have on demographic behaviour. Population estimates are often used alongside population projections to understand demand for education services or the structure of the working-age population. Some discussion of the implications of the UK leaving the EU and early evidence of downward trends in net long-term migration numbers can be found in **Chapter 9**. As our analysis shows, there is likely to be a continuing annual shortfall of engineers, which may be further exacerbated if migration patterns change.

7.3 ONS. 'National Population Projections: 2014-based Statistical Bulletin', October 2015.

7.2 – The UK workforce

Set in the context of a growing and ageing population, the UK workforce has expanded. According to the Labour Force Survey, between March and May 2017 there were 32 million people in work in the UK. This is 175,000 more than the previous quarter and 324,000 more than a year earlier.[7.4] Of these, 30.8 million were aged 16 to 64 years, the key group analysed in the working population. In total, 23.5 million people were working full time (364,000 more than for a year earlier) and 8.5 million were working part time (125,000 more than a year earlier).[7.5]

Labour market statistics: employment, unemployment, and economically inactive rates

Everyone aged 16 or above is classified as employed, unemployed, or economically inactive.

Employment estimates include all people in work, including those working part time.

People not working are classified as **unemployed** if they have been looking for work within the last 4 weeks and are able to start work in the next 2 weeks.

Jobless people who have not been looking for work within the last 4 weeks or who are unable to start work within the next 2 weeks are classified as economically inactive. Examples of **economically inactive** people include those not looking for work because they are students, looking after the family or home, because of illness or disability, or because they have retired.

In the second quarter of 2017, the employment rate (the proportion of people aged 16 to 64 who were in work) was 74.9%, the highest since comparable records began in 1971. Of these, 1.49 million or 4.5% were unemployed (not in work but seeking and available to work). This figure was down 64,000 on the previous quarter and 152,000 on a year earlier.

As **Figure 7.6** illustrates, both employment and unemployment rates varied by nation/region. For the 3 months ending May 2017, employment amongst those aged 16 to 64 years was highest in the South West (79.2%), closely followed by the South East (78.9%). These two regions also had the lowest unemployment rates (3.5% and 3.4%, respectively). In contrast, in Northern Ireland in the same period, employment and unemployment rates among those aged 16 to 64 stood at 68.7% and 5.3%, respectively. Unemployment was even higher in the North East (6.0%) and the West Midlands (5.9%).

Trends in employment rates also fluctuated by nation/region. The employment rate went up the most in the North East in the 12 months from Q2 2016. Despite growth of 1.5 percentage points to 72.4%, however, it still fell short of the national average. The South West and Yorkshire and the Humber saw comparatively large increases in their employment rates in that time, at 1.3%p and 1.0%p, respectively. Meanwhile, employment rates declined slightly in the East Midlands, the East of England, and Northern Ireland (down 0.3 percentage points or less).

Most regions saw decreases in Q2 2017 unemployment rates compared with a year ago. Exceptions were the East of England (up 0.5 percentage points), Wales and West Midlands, where the rates remained the same. The largest decrease was in Scotland at 1.7 percentage points, followed by the North East, at 1.4 percentage points.

Similarly, most regions saw a decline in their economic inactivity over the year. The exceptions to this were Scotland (with an increase in economic activity of 1.3 percentage points between

Figure 7.6 Employment, unemployment and inactivity rate by nation/region from March to May 2017 – UK

	Employment rate (%) aged 16 to 64	Change over 1 year (%p)	Unemployment rate (%) aged 16 and over	Change over 1 year (%p)	Inactivity rate (%) aged 16 to 64	Change over 1 year (%p)
England	75.4%	0.7%p ▲	4.5%	-0.4%p ▼	21.0%	-0.4%p ▼
North East	72.4%	1.5%p ▲	6.0%	-1.4%p ▼	22.9%	-0.5%p ▼
North West	74.0%	1.2%p ▲	4.3%	-0.6%p ▼	22.5%	-0.9%p ▼
Yorkshire and the Humber	73.3%	1.0%p ▲	4.8%	-0.9%p ▼	22.9%	-0.4%p ▼
East Midlands	74.7%	0.0%p	3.8%	-0.7%p ▼	22.3%	0.6%p ▲
West Midlands	71.8%	0.1%p ▲	5.9%	0.0%p	23.6%	-0.1%p ▲
East	77.6%	-0.3%p ▼	4.0%	0.5%p ▲	19.1%	0.0%p
London	74.0%	0.6%p ▲	5.5%	-0.3%p ▼	21.5%	-0.5%p ▼
South East	78.9%	0.6%p ▲	3.4%	-0.3%p ▼	18.3%	-0.3%p ▼
South West	79.2%	1.3%p ▲	3.5%	-0.5%p ▼	17.8%	-1.0%p ▼
Wales	72.6%	0.0%p	4.6%	0.0%p	23.8%	0.0%p
Scotland	74.1%	0.1%p ▲	3.8%	-1.7%p ▼	22.9%	1.3%p ▲
Northern Ireland	68.7%	-0.3%p ▼	5.3%	-0.6%p ▼	27.4%	0.8%p ▲
UK	**74.9%**	**0.5%p ▲**	**4.5%**	**-0.4%p ▼**	**21.5%**	**-0.1%p ▼**

Source: ONS, Labour Force Survey, March to May 2017
To view this table with numbers from 2016 and 2017, see **Figure 7.6** in our Excel resource.

7.4 ONS. 'UK Labour Market Statistical Bulletin: July 2017', July 2017.
7.5 ONS. 'Full-time, part-time and temporary workers (seasonally adjusted)', September 2017.

2016 and 2017), Northern Ireland, and the East Midlands (with an increase of 0.8 and 0.6 percentage points). There was no change in the East. Notably, Northern Ireland's economic inactivity stood at 27.4%, significantly higher than the UK rate of 21.5%.

Nationality profile

A somewhat contentious aspect of the workforce currently is its nationality profile. Over the 20-year period from Q1 1997 to Q1 2017, the proportion of non UK nationals in the UK workforce increased from 3.5% to 11.1%. Of the 32 million in employment, 3.55 million were non UK nationals in March 2017, an increase of 207,000 from the previous year.

Non UK nationals from the EU working in the UK increased by 171,000 to 2.32 million from the previous year, while workers from outside the EU increased in number by 35,000, to 1.23 million. Sixty four per cent of non UK nationals working in the UK in March 2017 were from the EU. Data from the Labour Force Survey shows that 7.7% of workers in the EngineeringUK sectoral footprint in 2016 were EU nationals, compared with 6.1% in non engineering sectors. In the first quarter of 2017, EU nationals made up a higher share of the workforce in key engineering-related industries, including manufacturing (11.5%), construction (8.7%) and professional, scientific and technical activities (8.1%) than across the economy overall (7.3%).[7.6] However, as discussed in **Chapter 10**, evidence suggests that the UK's vote to leave the EU has had an impact on net migration numbers. It is also worth noting that these figures reflect the number of people in work. They can't be used to estimate the proportion of new jobs that have been filled by non UK workers, or as a proxy for flows of foreign migrants into the UK.

Ethnic profile

Employment, unemployment and inactivity rates also vary by ethnicity. Data from the Office for National Statistics from April to June 2017 shows that 87.8% of the 32 million people working in the UK were white, and the remaining 12.2% were from a BME background (**Figure 7.7**).[7.7] Even though unemployment rates for different ethnicities have decreased over the past years, they are still higher than for their white peers: only 3.9% of those from a white ethnic group were unemployed, compared to 7.8% of people from a BME background.[7.8]

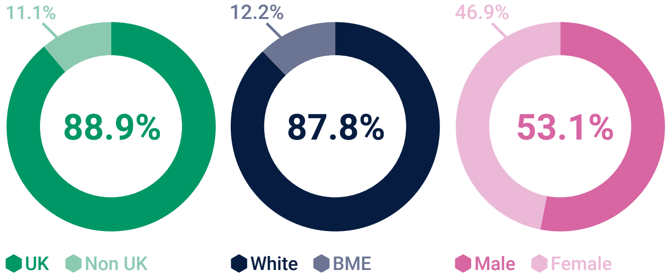
Gender profile

From April to June 2017, of the total 32 million in employment, including full time, part time and temporary work, 46.9% were women. This is only slightly lower than the overall proportion of women in the population (50.7%).[7.9] However, there were clear gender differences in the mode of working. Among those employed, 46.1% of men worked full time, more than 1.5 times the proportion of women (27.4%). What's more, as discussed in **Chapter 9**, men working full time earn more than women on average.

Some 5.66 million people worked in UK engineering enterprises in 2016, constituting 18.9% of the UK's total workforce.

A greater proportion of unemployed people were men (54.9% of 1.46 million) while nearly three in five economically inactive people were women (58.5%).[7.10]

Figure 7.7 Proportions of UK workforce by nationality profile, ethnic profile and gender in 2017 – UK



Source: ONS, Labour Force Survey, April to June 2017

There is not a universally agreed definition of the engineering sector in the UK. The engineering workforce is defined here on the basis of the latest EngineeringUK sectoral footprint, using SIC codes to identify people working in engineering industries. There are also some breakdowns using the occupational footprint - that is people working in occupations defined using the Standard Occupational Classification (SOC) as being engineering occupations. The EngineeringUK footprint is described more in detail in **Chapter 2**.

In this chapter we use:

- The sectoral footprint – or 'engineering sector' – to describe all workers in the industries included in the footprint, regardless of their occupation. Therefore, these figures cover all those working in engineering sector companies, whether or not they were employed in an engineering or related role. Whenever the analysis covers specific categories of workers within the engineering sector – for example, workers in engineering occupations within the engineering sector – this is explicitly stated.
- The occupational footprint – or 'engineering occupations' –to describe all workers in the occupations covered by this footprint, regardless of their sector of employment. Therefore, these figures include all workers in engineering or related roles, whether or not they were working in the engineering sector. Whenever the analysis covers specific categories of workers within engineering occupations – for example, workers in engineering occupations outside of the engineering sector - this is explicitly stated.

7.6 House of Commons Library. 'Mitigation statistics', January 2018.
7.7 ONS. 'Labour market status by ethnic group', August 2017.
7.8 House of Commons Library. 'Unemployment by ethnic background', August 2017
7.9 ONS. 'Full-time, part-time and temporary workers (seasonally adjusted)', September 2017.
7.10 ONS. 'Labour market status by ethnic group', August 2017.

Figure 7.8 Employment in VAT and/or PAYE based enterprises in engineering major industries from 2009 to 2016 – UK

	Mining and quarrying		Manufacturing		Construction	
Year	**No.**	**% footprint**	**No.**	**% footprint**	**No.**	**% footprint**
2009	56,475	1.0%	2,688,338	45.6%	1,116,866	18.9%
2010	53,867	1.0%	2,496,033	44.5%	1,058,944	18.9%
2011	55,768	1.0%	2,390,363	44.3%	984,118	18.3%
2012	56,494	1.0%	2,390,294	44.0%	956,893	17.6%
2013	57,575	1.1%	2,380,526	43.8%	949,307	17.5%
2014	56,613	1.0%	2,393,165	43.3%	952,275	17.2%
2015	61,309	1.1%	2,422,628	42.8%	978,233	17.3%
2016	59,446	1.0%	2,394,240	42.3%	975,338	17.2%

Source: ONS, Inter Department Business Register 2009-2016
To view this table by nation/region, see **Figure 7.8** in our Excel resource.

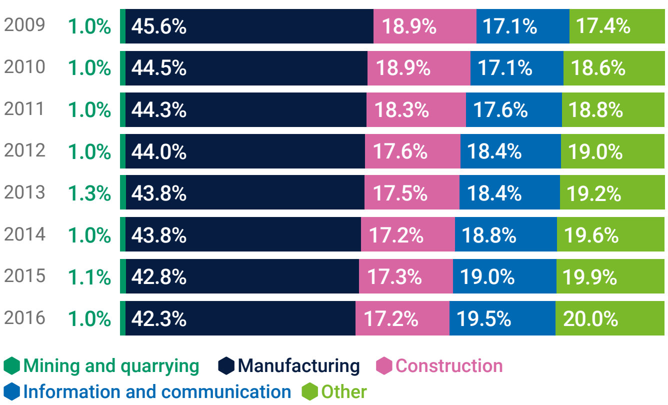
7.3 – Employment in the engineering sector

Employment by industry

Engineering accounts for a significant proportion of the overall UK workforce. The Office for National Statistics analysed the engineering sector on EngineeringUK's behalf and found that some 5.66 million people worked in UK engineering enterprises in 2016.[7.11] This constitutes 18.9% of the UK's total workforce. These figures are based on employment within VAT and/or PAYE based enterprises in the engineering sector, as defined by UK SIC 2007 classes agreed by EngineeringUK, Engineering Council, and the Royal Academy of Engineering to be 'engineering'.

Notably, as a proportion of total employment, the number of employees within the EngineeringUK sectoral footprint in 2016 has decreased by 2.1 percentage points since 2009 (**Figure 7.8**). However, it is clear that some engineering industries are expanding while others are in decline. The number of workers in engineering-related the information and communications industry, for example, has increased by 9.4% relative to 2009, and those other than the major industries within the footprint has increased by 10.3% overall. In contrast, employment in manufacturing has shrunk by nearly 10.9%, though it continues to account for 42.3% of employment in engineering enterprises.

Figure 7.9 Employment in VAT and/or PAYE based enterprises in engineering major industries from 2009 to 2016 – UK



Source: ONS, Inter Departmental Business register 2009-2016

Further discussion on the changing composition of the engineering sector and emerging industries can be found in **Chapter 2**. The number of people employed in construction has also decreased by 12.7%, while for mining and quarrying it has stayed virtually static.

As shown on **Figure 7.8** and **Figure 7.9**, those working in the EngineeringUK sectoral footprint were most commonly employed in manufacturing (42.3%), followed by information and communication (19.5%) and construction (17.2%). Mining and quarrying, historically an important aspect of the UK engineering sector, now accounts for just 1% of employment within the footprint. The remaining 20% of employees working in engineering enterprises did so in 'other' industries: agriculture, electricity, water, repair of motor vehicles, transportation, professional, administrative, and public services. Employment in information and communication has steadily grown over the years, both in absolute numbers and as a proportion of the engineering footprint. A recent employer survey by the Institution of Engineering and Technology (IET) suggests at least some of this growth is for engineering/technical roles. The survey identifies information and communication as the industry with the highest proportion of firms reporting an increase in employees in engineering and technical roles over the last 3 years.[7.12]

A separate, more detailed analysis of the Labour Force Survey was carried out by the Institute of Employment Studies on EngineeringUK's behalf (**Figure 7.10**).[7.13] It shows that for the second quarter of 2016, construction accounted for 23.7% of all those working in the engineering sector, with communications/computing (11.2%) and professional services (10.0%) also making up a sizeable share.

7.11 IES. 'The Demographic Characteristics of the Engineering Workforce', 2017
7.12 IET. 'Skills & demand in industry survey', 2017.
7.13 IES. 'The Demographic Characteristics of the Engineering Workforce', 2017.

	Information and communication		Other		Engineering footprint		Whole economy
	No.	% footprint	No.	% footprint	No.	% whole economy	No.
	1,008,685	17.1%	1,024,795	17.4%	5,895,159	21.0%	28,091,440
	956,945	17.1%	1,041,977	18.6%	5,607,766	20.2%	27,807,293
	948,084	17.6%	1,012,315	18.8%	5,390,648	19.6%	27,505,675
	997,375	18.4%	1,031,252	19.0%	5,432,308	19.5%	27,809,664
	998,494	18.4%	1,044,616	19.2%	5,430,518	19.3%	28,112,546
	1,041,278	18.8%	1,085,892	19.6%	5,529,223	19.3%	28,694,737
	1,072,732	19.0%	1,123,860	19.9%	5,658,762	19.1%	29,583,931
	1,103,865	19.5%	1,131,062	20.0%	5,663,951	18.9%	29,960,163

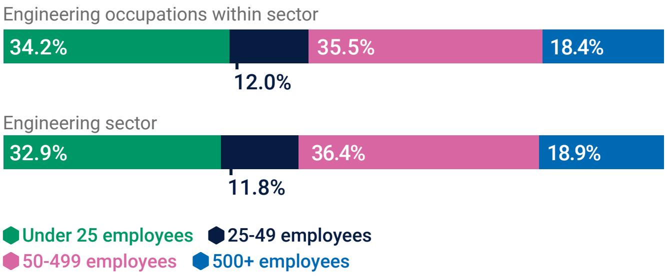
Figure 7.10 Employment by industry within the EngineeringUK SIC footprint (including engineering occupations) in 2016 – UK

	Engineering sector		Engineering occupations within sector	
	No.	%	No.	%
Mining etc.	108,700	1.5%	69,500	1.6%
Food, drink, tobacco	368,400	5.0%	183,100	4.3%
Textiles and clothing	138,500	1.9%	38,500	0.9%
Wood and paper	238,300	3.3%	84,800	2.0%
Non-metallic manufacturing	489,500	6.7%	215,000	5.0%
Metal manufacturing	354,600	4.8%	241,600	5.7%
Electronic and electrical	241,600	3.3%	132,200	3.1%
Machinery	290,200	4.0%	167,800	3.9%
Vehicles	426,000	5.8%	293,200	6.9%
Other manufacturing	207,200	2.8%	78,300	1.8%
Repair of machinery	232,000	3.2%	162,500	3.8%
Energy, water etc.	312,900	4.3%	144,700	3.4%
Construction	1,734,600	23.7%	1,188,300	27.8%
Distribution and transport	281,500	3.8%	171,000	4.0%
Communications and computing	822,800	11.2%	578,200	13.5%
Professional services	733,600	10.0%	405,100	9.5%
Defence and other sectors	339,400	4.6%	116,100	2.7%
All engineering industries	**7,319,800**	**100.0%**	**4,269,900**	**100.0%**

Source: ONS, Labour Force Survey, April to June 2016

Most of those working within the engineering sector (whether or not they where employed in engineering occupations) did so in businesses with between 50 and 499 employees. As shown on **Figure 7.11**, around 1 in 3 employees in the engineering sector (32.9%) worked for businesses with fewer than 25 employees, 11.8% for businesses with between 25 and 49 employees, 36.4% for businesses with between 50 and 499 employees, and 18.9% for businesses with 500 or more employees. In comparison with other sectors, there was a slightly lower proportion of employees in businesses with under 50 employees (44.7% in engineering compared with 48.7% in other sectors), and a slightly higher proportion in businesses with between 50 and 499 employers (36.4% in engineering compared with 32.4% in other sectors).

Figure 7.11 Employment within the EngineeringUK SIC footprint by enterprise size in 2016 – UK

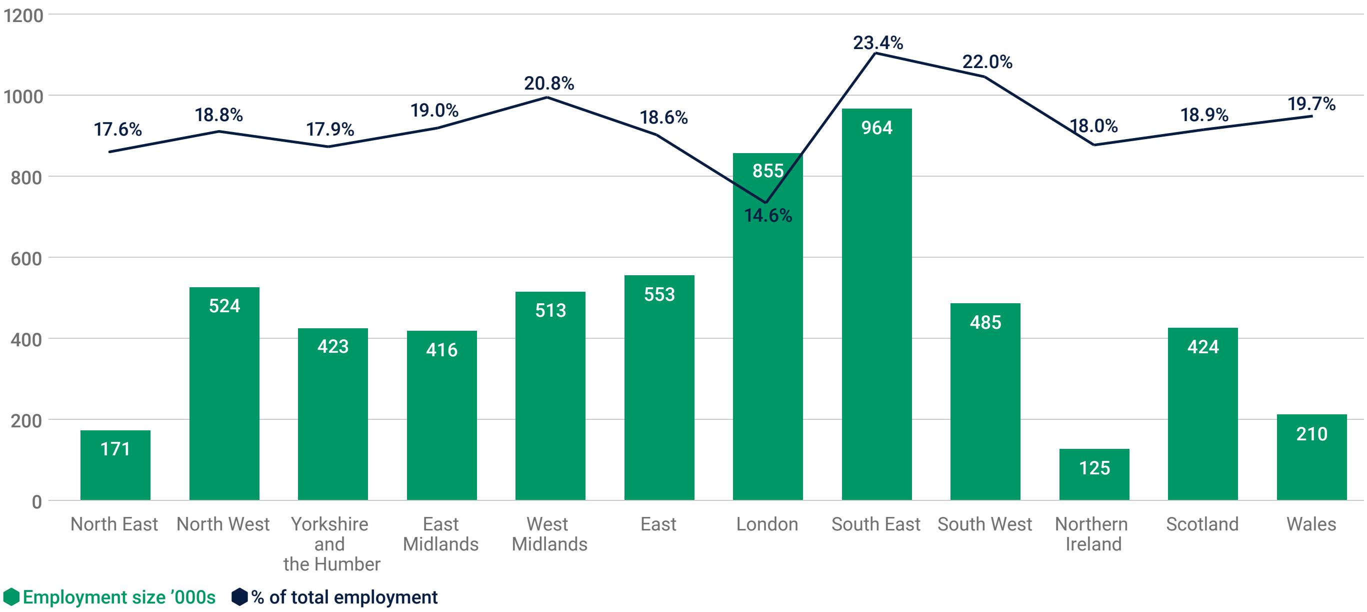


Source: ONS, Labour Force Survey, April to June 2016

However, there was considerable variation in employer size within the engineering sector by industry. Distribution and transport had the highest proportion of engineering employees in businesses with fewer than 25 employees (69.7%). This was followed by construction (46.1%), repair of machinery (40.0%), wood and paper manufacturing (39.0%), metal manufacturing (38.1%), textiles and clothing (35.3%) and professional services (35.1%). At the other end of the scale, vehicle manufacturing had the highest proportion of employees in large businesses with 500 or more employees (48.8%), followed by defence and other sectors (46.1%), food, drink and tobacco (26.9%), and energy and water supply (26.5%).

Analysis by ONS of IDBR data included a breakdown of the engineering sector by employer size and broader industry groups. It found a growing trend between 2009 and 2016 toward employment in smaller enterprises. This was evident in most industries other than manufacturing, including: construction, repair of motor vehicles, information and communication and 'other' industries. **Chapter 2** explores the changing composition of the engineering sector in more detail.

Figure 7.12 Employment within the EngineeringUK SIC footprint by nation/region and percentage of total employment in 2016 – UK



Source: ONS, Labour Force Survey, April to June 2016

Figure 7.13 Employment within the EngineeringUK SIC footprint by nation/region and percentage of total employment in 2016 – UK

	Mining and quarrying	Manufacturing	Construction	Information and communications	Other	Whole economy		Change over time	
	% footprint	% footprint	% footprint	% footprint	% footprint	% engineering footprint	Total no.	Change over 1 year (%)	Change over 5 years (%)
England	0.5%	41.8%	16.8%	21.0%	19.9%	18.9%	25,957,914	-0.1% ▼	5.3% ▲
North East	1.0%	52.2%	18.6%	7.9%	20.2%	17.6%	971,516	-0.1% ▼	7.6% ▲
North West	–	53.1%	16.4%	–	18.7%	18.8%	2,791,855	1.0% ▲	7.1% ▲
Yorkshire and the Humber	0.3%	56.4%	17.4%	10.3%	15.6%	17.9%	2,369,015	0.5% ▲	5.1% ▲
East Midlands	1.3%	59.2%	17.1%	8.9%	13.4%	19.0%	2,191,198	3.0% ▲	9.0% ▲
West Midlands	–	58.0%	13.4%	–	19.3%	20.8%	2,462,447	0.9% ▲	3.2% ▲
East	0.2%	39.4%	20.6%	17.6%	22.2%	18.6%	2,981,429	1.4% ▲	-8.9% ▼
London	0.9%	19.0%	14.1%	46.1%	19.9%	14.6%	5,857,071	1.6% ▲	28.0% ▲
South East	0.4%	34.0%	18.2%	28.5%	19.0%	23.4%	4,126,667	-4.9% ▼	0.3% ▲
South West	–	39.1%	17.2%	–	29.8%	22.0%	2,206,716	-0.2% ▼	-1.2% ▼
Wales	0.5%	58.6%	19.0%	6.6%	15.2%	19.7%	1,067,897	1.9% ▲	2.2% ▲
Scotland	7.3%	36.6%	19.4%	11.0%	25.7%	18.9%	2,240,311	0.4% ▲	5.3% ▲
Northern Ireland	1.1%	54.6%	22.7%	9.3%	12.4%	18.0%	694,041	4.7% ▲	0.1% ▲
UK	**1.0%**	**42.3%**	**17.2%**	**19.5%**	**20.0%**	**18.9%**	**29,960,163**	**0.1%** ▲	**5.1%** ▲

Source: ONS, Inter Departmental Business Register 2016
'–' denotes suppressed data. Statistical disclosure control methodology has been applied to ensure no individual or organisation is identifiable.

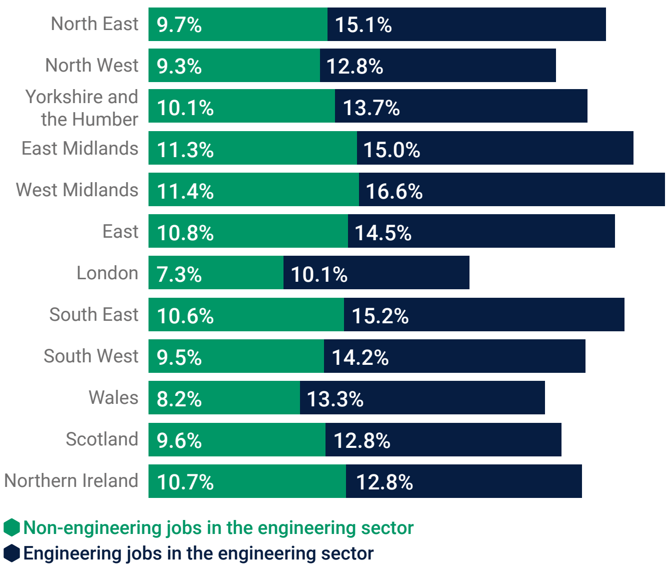
Employment by region

Employees working in engineering enterprises – including those in engineering and non-engineering roles – were most concentrated in the South East (at nearly a million and comprising 23.4% of total employment in the region), followed by London (at 855,000 and 14.6% of total employment in the region). This was around eight times greater than the number of employees working in engineering enterprises in Northern Ireland (125,000; **Figure 7.12**).

There were also clear regional variations in the types of industries that engineering sector workers were employed in. For example, in Scotland, 7.3% worked in mining and quarrying, more than seven times the overall UK figure of 1.0% (**Figure 7.13**).[7.14] There were particularly large regional variations in information and communication: just 6.6% of all engineering sector employees worked in this industry in Wales, compared with 46.1% in London. Likewise, comparatively manufacturing accounted for just 19% of engineering sector employment in London, compared with 42.3% in the UK as a whole.

London, however, was also the only region or nation where less than 20% of the regional workforce were employed in the engineering sector. (**Figure 7.14**) shows that in all other parts of the UK, people in non-engineering roles within the engineering sector represented between 8% and 11% of regional employment, and those in engineering roles between 13% and 17%. Overall, both kinds of employment had the highest concentration in the West Midlands.

Figure 7.14 Employment within the EngineeringUK SIC footprint by nation/region (including engineering and non-engineering occcupations) in 2016 – UK



Source: ONS, Labour Force Survey, April to June 2016

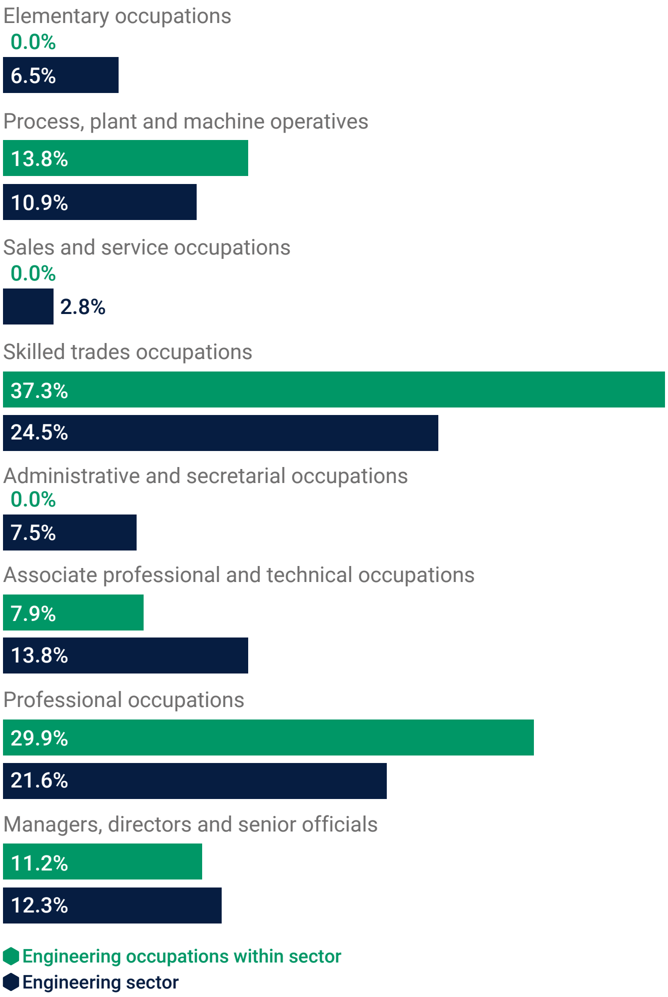
7.14 ONS. 'Analysis of the engineering industry by size and Region 2009 to 2016', July 2017.

Employment by occupation

Under a quarter (24.5%) of all workers in the EngineeringUK sectoral footprint were employed in 'skilled trades occupations', followed by 'professional occupations' (21.6%), 'associate professional and technical occupations' (13.8%), 'managerial occupations' (12.3%) and 'process, plant and machine operatives' (10.9%) (**Figure 7.15**).[7.15]

Skilled trades occupations also make up the largest share of workers employed in engineering occupations within the engineering sector, (37.3%), followed by professional occupations (29.9%) and process, plant and machine operatives (13.8%).

Figure 7.15 Employment within the EngineeringUK SIC footprint (including engineering occupations) by occupation in 2016 – UK



Source: ONS, Labour Force Survey, April to June 2016

Figure 7.16 shows that there was substantial variation in the occupational profile of employment in the different engineering industries. Key points to note are:

- over three quarters of workers in 'communications and computing' and 'professional services' were classed as 'managerial, professional, technical', compared with 16.2% those in 'distribution and transport', and just over a quarter of those in 'food, drink and tobacco', and 'wood and paper'
- the proportion of other non-manual workers was fairly uniform across the industries, ranging from 7% to 15%
- the proportion of skilled craft workers was highest in 'distribution and transport' (54.8%), followed by 'construction' (43.7%), 'repair of machinery' (40.3%), and 'metal manufacturing' (36.0%)
- 'food, drink and tobacco' had the highest proportion of semi-skilled and unskilled workers (53.3%), followed by 'textiles and clothing' (31.8%), 'machinery' (28.0%), 'wood and paper' (27.6%), 'non-metallic manufacturing' (26.0%) and 'energy and water supply' (25.0%)

Figure 7.16 Employment within the EngineeringUK SIC footprint by occupation and industry in 2016 – UK

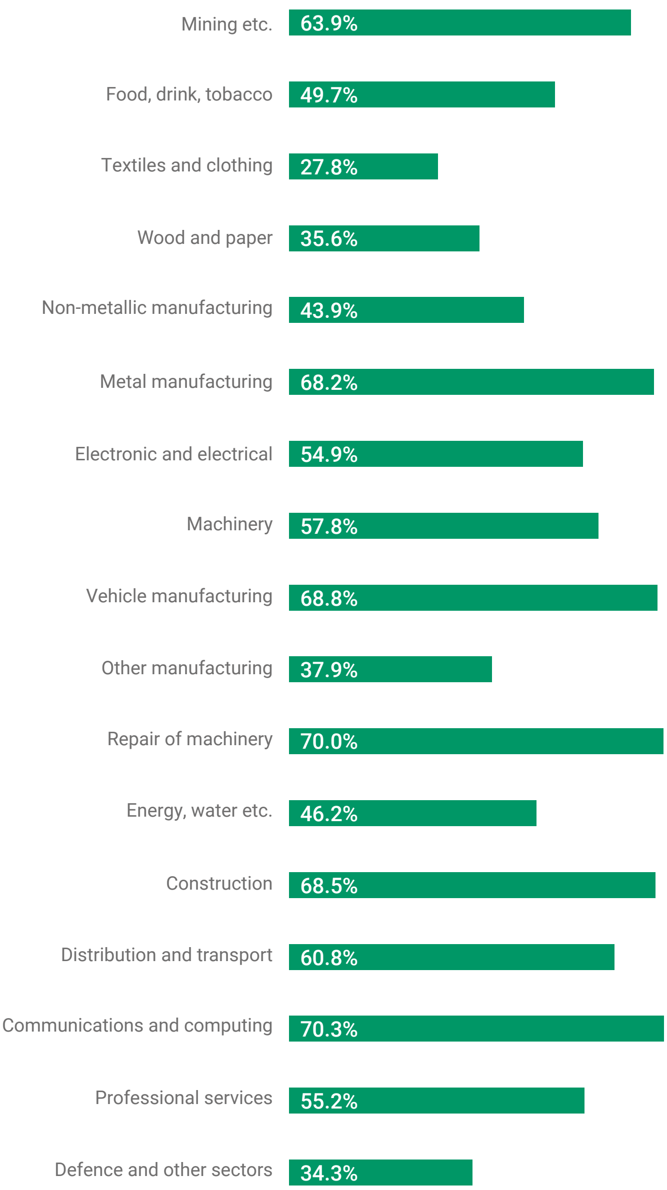
	Managerial, professional, technical	Other non-manual	Skilled craft	Semi- and unskilled
Mining etc.	63.8%	6.9%	15.7%	13.6%
Food, drink, tobacco	27.7%	8.6%	10.4%	53.3%
Textiles and clothing	35.4%	11.3%	21.5%	31.8%
Wood and paper	26.6%	13.8%	32.0%	27.6%
Non-metallic manufacturing	49.0%	11.7%	13.4%	26.0%
Metal manufacturing	35.6%	9.7%	36.0%	18.7%
Electronic and electrical	61.3%	13.4%	9.8%	15.4%
Machinery	39.8%	10.8%	21.4%	28.0%
Vehicle manufacturing	43.3%	9.1%	25.1%	22.5%
Other manufacturing	41.5%	15.0%	21.1%	22.3%
Repair of machinery	39.3%	8.3%	40.3%	12.1%
Energy, water etc.	44.8%	14.4%	15.8%	25.0%
Construction	30.5%	8.3%	43.7%	17.5%
Distribution and transport	16.2%	14.9%	54.8%	14.2%
Communications and computing	85.8%	8.6%	4.6%	1.1%
Professional services	78.9%	10.4%	7.7%	3.0%
Defence and other	63.9%	14.3%	16.4%	5.3%
All engineering industries	**47.7%**	**10.4%**	**24.5%**	**17.4%**

Source: ONS, Labour Force Survey, April to June 2016

7.15 IES. 'The Demographic Characteristics of the Engineering Workforce', 2017.

Just under three fifths (58.0%) of workers in the EngineeringUK sectoral footprint were also in the occupational footprint. In other words, they not only worked for engineering businesses, but carried out engineering-related roles within those businesses. The proportion was highest in 'communications/computing', at 70.3%, closely followed by 'repair of machinery' (70.0%), 'vehicle manufacturing' (68.8%), and 'metal manufacturing' (68.2%), while it was lowest in 'textiles and clothing' (27.8%), 'defence and other' (34.3%), 'wood and paper' (35.6%) and 'other manufacturing' (37.9%) (**Figure 7.17**). This suggests that the need for engineering skills is higher in some engineering-related industries than others, which corresponds to our demand forecasts discussed in **Chapter 10**.

Figure 7.17 Proportion of workers in the EngineeringUK SOC footprint by industry in 2016 – UK



% of workers in the EngineeringUK occupational footprint

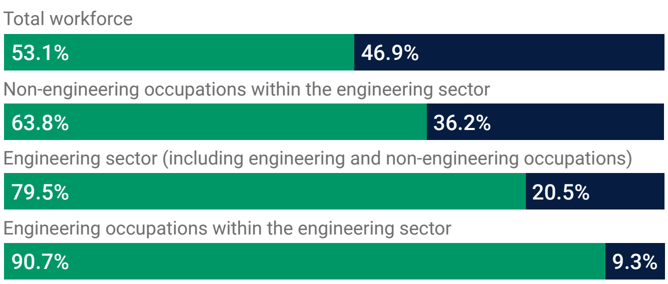
Source: ONS, Labour Force Survey, April to June 2016

7.4 – Personal characteristics of the engineering workforce

It is clear that the profile of engineering sector workers does not reflect the diversity of the overall working population, particularly in respect of gender. While women comprised 46.9% of the overall UK workforce, they only made up 20.5% of those working in the engineering sector in 2016 (**Figure 7.18**). There were, however, some variations by industry (**Figure 7.19**). 'Textiles and clothing' was the only industry with a broadly balanced gender profile (51.7% men, 48.3% women). In contrast, employment in many engineering industries had a heavily male-biased profile, including in 'repair of machinery' (88.4%), 'mining etc' (87.7%), 'construction' (87.4%), and 'vehicle manufacturing' (86.5%).[7.16]

Gender diversity was even lower among those working in engineering-related occupations within the sectoral footprint. Around 1 in 10 (9.3%) workers in engineering-related roles within the engineering sector are female. This compares unfavourably with other type of workers in the engineering sector: 36.2% of workers in the engineering sector but not in engineering occupations are female.

Figure 7.18 Gender profile of the total workforce and engineering sector workers (including engineering and non-engineering occupations) in 2016 – UK

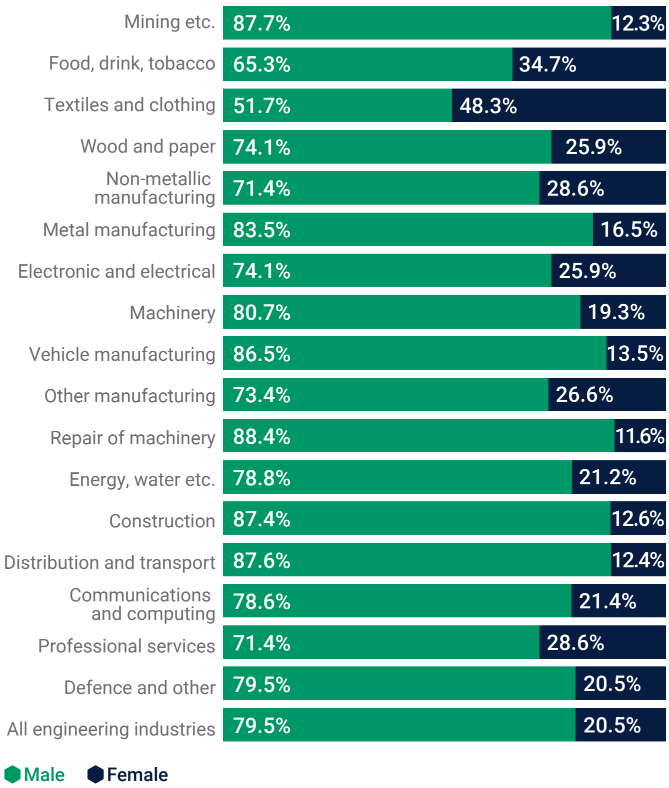


Male Female

Source: ONS, Labour Force Survey, April to June 2016

7.16 IES. 'The Demographic Characteristics of the Engineering Workforce', 2017.

Figure 7.19 Employment within the EngineeringUK SIC footprint by gender and industry in 2016 – UK



Source: ONS, Labour Force Survey, April to June 2016

Likewise, only 8.1% and 7.8% of all workers in the engineering sector and of those in engineering roles within the sector were from ethnic minority groups, compared with 12.0% of the UK workforce, and 12.2% of the broader population. As **Figure 7.20** shows, ethnic minorities were particularly underrepresented in 'metal manufacturing' (3.9%), 'other manufacturing' (5.0%), and 'energy and water supply' (5.5%). However, they were overrepresented in 'communications/computing' (15.9%) and 'textiles and clothing' (15.5%).

Similarly, among those in engineering-based roles within the engineering sector, ethnic minorities represented 5% or less of workers in 'metal manufacturing' (4.6%), 'energy and water supply' (4.6%) and 'machinery' (4.8%), and made up a similar or higher proportion than the all-population average of 12% in 'communications/computing' (16.6%) and 'food, drink and tobacco' (11.9%).

Case study – Addressing gender diversity in the tech sectors

Doniya Soni, Policy Manager, techUK

It is no secret that there is a gender diversity problem in the tech sector. Women occupy just 17% of tech jobs. Women make up only 20% of tech founders, and only 4% of software engineers. Digital businesses are innovative and pioneering in a number of ways, but we still face a great challenge in ensuring our sector workforce represents its diverse and thriving customer base.

techUK is working with its members and partners to address the issue through targeted intervention at key points in the pipeline.

We are working with the WISE campaign to take the People Like Me project digital.[7.17] Currently, a test works by allowing girls to use their natural tendency to use adjectives to define themselves. The test 'translates' their descriptions into the types of STEM careers that could interest them. Since it was piloted, nearly 500 schools have used People Like Me. Thanks to its new approach to personal analysis and career discussions, more than half (58%) of those who have taken the test showed an interest in a career in STEM. We are now taking the project online.

We also launched our Returners' Hub on International Women's Day this year.[7.18] The hub hosts free resources for individuals who are looking to get back to the sector after a career break. It also features a number of tech companies who either run dedicated returners' programmes, or who have a flexible working policy aimed at attracting more returners. Since launch, the Returners' Hub has been one of the most visited pages on the techUK website and we are collating evidence on the impact it has had on returners looking for a role.

Lastly, techUK is a proud supporter of the Tech Talent Charter (TTC).[7.19] The TTC is a commitment by organisations to a set of undertakings that aim to deliver greater diversity in the UK's tech workforce, so that it better reflects the make-up of the population. Through commitment and data sharing, the TTC will be able to report on the progress of its signatories and identify problem areas.

7.17 techUK. 'Successful Programme Changing Girls' Minds About STEM Careers to go Digital', January 2017.
7.18 techUK. 'Returners Hub', 2017.
7.19 Tech Talent Charter, 2017.

Figure 7.20 Employment within the EngineeringUK SIC footprint (including engineering occupations) by ethnicity and industry in 2014-16 – UK

	Black %		Asian %		Mixed %		Other %		BME total	
	Eng. sector (all jobs)	Eng. jobs within sector	Eng. sector (all jobs)	Eng. jobs within sector	Eng. sector (all jobs)	Eng. jobs within sector	Eng. sector (all jobs)	Eng. jobs within sector	Eng. sector (all jobs)	Eng. jobs within sector
Mining etc.	0.7%	0.6%	2.9%	3.3%	0.7%	0.6%	2.5%	2.4%	6.9%	6.9%
Food, drink, tobacco	1.2%	1.4%	8.2%	8.7%	0.9%	0.9%	1.3%	0.9%	11.6%	11.9%
Textiles and clothing	1.1%	0.0%	12.2%	8.1%	0.4%	0.0%	1.7%	0.0%	15.5%	8.1%
Wood and paper	0.7%	1.2%	3.5%	2.0%	1.3%	1.1%	1.0%	1.7%	6.5%	6.1%
Non-metallic man	1.7%	1.3%	4.2%	3.1%	0.4%	0.6%	0.8%	0.7%	7.0%	5.8%
Metal manufacturing	0.7%	0.9%	2.2%	2.2%	0.5%	0.8%	0.5%	0.6%	3.9%	4.6%
Electronic/electrical	1.5%	1.8%	6.4%	7.5%	0.6%	0.5%	1.3%	0.9%	9.7%	10.6%
Machinery	0.6%	0.5%	3.5%	3.0%	0.5%	0.5%	0.7%	0.8%	5.3%	4.8%
Vehicles	1.0%	1.0%	4.0%	4.3%	0.9%	1.0%	0.7%	0.9%	6.6%	7.2%
Other manufacturing	0.5%	0.9%	3.0%	3.0%	0.3%	0.3%	1.2%	1.7%	5.0%	5.8%
Repair of machinery	1.0%	1.2%	2.1%	2.1%	0.9%	1.0%	0.5%	0.7%	4.5%	5.0%
Energy and water supply	0.8%	1.1%	3.3%	3.2%	0.3%	0.1%	1.1%	0.1%	5.5%	4.6%
Construction	1.5%	1.3%	2.8%	2.6%	0.5%	0.5%	0.9%	0.5%	5.7%	4.9%
Distribution/transport	1.7%	1.6%	3.6%	3.9%	0.8%	0.4%	2.4%	1.0%	8.6%	6.9%
Communications/computing	1.9%	1.9%	11.6%	12.1%	0.9%	1.1%	1.6%	1.5%	15.9%	16.6%
Professional services	1.2%	1.1%	5.8%	6.1%	1.1%	0.8%	1.2%	1.4%	9.3%	9.4%
Defence and other	2.4%	2.3%	3.6%	3.8%	0.9%	0.0%	0.5%	0.3%	7.4%	6.3%
All engineering industries	**1.3%**	**1.3%**	**4.9%**	**4.9%**	**0.7%**	**0.7%**	**1.1%**	**0.9%**	**8.1%**	**7.8%**

Source: ONS, Labour Force Survey, average of April to June 2014-2016 quarters

In 2016, the average age of workers in the engineering sector (including those in engineering and non-engineering roles) was slightly, but only very slightly, older than that of the UK workforce as a whole (41.9 years compared with 41.2 years). 'Mining etc' had the oldest workers on average, with a mean age of 44.4 years, while 'defence and other' had the youngest, at 40.0 years on average (**Figure 7.21**). Workers in engineering occupations within engineering industries are slightly younger than in the engineering footprint, at 41.7 years.

Figure 7.21 Employment within the EngineeringUK SIC footprint by mean age (2016) – UK

Defence and other
40.0

Communications and computing
40.1

Distribution and transport
40.5

Food, drink, tobacco
40.6

Construction
41.8

Total engineering
41.9

Energy, water etc.
42.1

Non-metallic manufacturing
42.2

Electronic and electrical
42.2

Vehicle manufacturing
42.5

Wood and paper
42.7

Other manufacturing
42.9

Repair of machinery
43.0

Professional services
43.0

Textiles and clothing
43.1

Machinery
43.1

Metal manufacturing
43.2

Mining etc.
44.4

Mean age (years)

Source: ONS, Labour Force Survey, April to June 2016

7.5 – Engineering employment across the economy

The sections above explored the characteristics of workers in the Engineering UK sectoral footprint, whether or not they were employed in engineering roles. This section examines the profile of workers in the EngineeringUK occupational footprint (ie in core or related engineering jobs) across the economy, including a breakdown of those who employed outside of the engineering sector. A detailed description of our engineering footprint can be found in **Chapter 2**.

Employment by industry

It is apparent that a significant proportion of the 6 million people working in engineering occupations in 2016 do so outside of the sectoral footprint – that is, engineering industries. In 2016, there were 1.7 million workers in engineering-related roles in sectors other than engineering in 2016 (**Figure 7.22**). This represents 28.4% of all workers in engineering occupations, attesting to the ubiquity of engineering skills across industry.

Over half of these workers were employed in three industries: construction (17.5%), wholesale and retail (17.4%), and business services (16.0%). This is rather different from the profile of workers in engineering roles within the sectoral footprint (see section 7.3), where construction accounts for the greatest proportion (27.8%) of those workers, followed by communications and computing (13.5%) and professional services (9.5%). This suggests that the engineering skills requirements of employers may, to a certain extent, vary depending on whether they operate in engineering sectors or not.

Figure 7.22 Engineering occupations employment by industry outside of the EngineeringUK SIC footprint in 2016 – UK

	No.	%
Agriculture	16,500	1.0%
Food, drink, tobacco	10,500	0.6%
Energy, water etc.	13,200	0.8%
Construction	296,600	17.5%
Wholesale and retail	294,600	17.4%
Transport and logistics	162,800	9.6%
Hotels and restaurants	23,400	1.4%
Publishing and broadcasting	58,400	3.4%
Financial services	132,800	7.8%
Business services	272,800	16.1%
Public administration	133,800	7.9%
Education	109,900	6.5%
Health and social care	82,700	4.9%
Other services	89,000	5.2%
All engineering industries	**1,697,000**	**100.0%**

Source: ONS, Labour Force Survey, April to June 2016

Employment by business size

As was the case for workers in the engineering sector (including all occupations), a significant minority (43.1%) of those in the EngineeringUK occupational footprint worked for small businesses (those with less than 50 employees). **Figure 7.23** shows that these workers were equally likely to work for medium-large businesses with 50-499 employees (36%), and more likely to be employed by businesses with more than 500 employees (21%, compared with 19% for the engineering sectoral footprint). Those in engineering-related occupations outside engineering sectors were particularly likely to be working for large employers, with 28% employed by businesses with more than 500 employees.

Employment by region

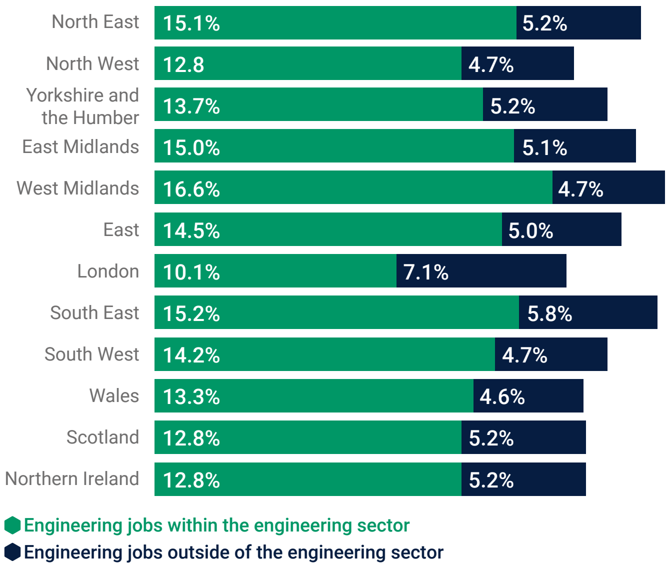
Looking at those working in engineering occupations across all sectors, the highest concentrations were found in the South East and the West Midlands. In these two regions, employment in engineering occupations across all sectors accounted for around 21% of the regional workforce each, with those working outside engineering sectors representing around 6% in the former and 5% in the latter (**Figure 7.24**). However, it is London that had the highest proportion of workers in engineering-related occupations outside of the engineering sector (7.1%), with Wales lagging behind all other regions on this measure (4.6%).

Figure 7.23 Employment by size of employer, EngineeringUK sectoral footprint (including for engineering occupations) and occupational footprint in 2016 – UK

	Engineering sector		Engineering occupations within sector		Engineering occupations	
	No.	%	No.	%	No.	%
Under 25 employees	2,029,000	32.9%	1,183,500	34.2%	1,558,900	32.1%
25-49 employees	730,500	11.8%	414,800	12.0%	532,800	11.0%
50-499 employees	2,244,300	36.4%	1,228,800	35.5%	1,745,700	35.9%
500+ employees	1,169,000	18.9%	637,700	18.4%	1,022,500	21.0%
All employees	**6,172,900**	**100.0%**	**3,464,800**	**100%**	**4,860,000**	**100.0%**

Source: ONS, Labour Force Survey, April to June 2016

Figure 7.24 EngineeringUK occupational footprint by nation/region and percentage of total employment in 2016 – UK

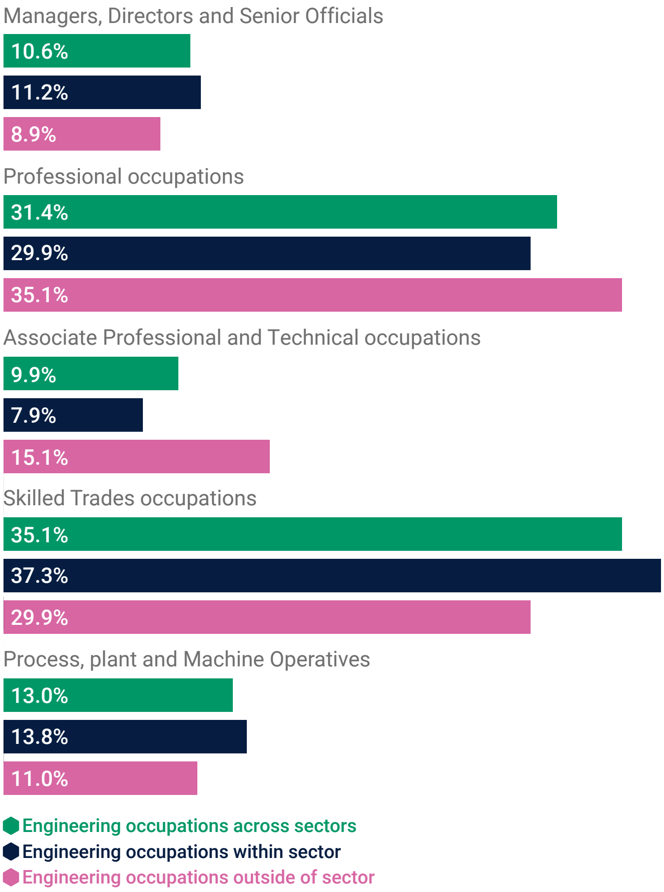


Source: ONS, Labour Force Survey, April to June 2016

Employment by occupation

Relative to workers in engineering-related occupations within the engineering sector, those in engineering-related roles outside of the engineering sector were more likely to be in professional and associate professional occupations (**Figure 7.25**). Professionals represent the largest occupational group (35.1%), followed by skilled trades occupations (29.9%) and associate professional and technical occupations (15.1%).

Figure 7.25 Proportion of workers in the EngineeringUK occupational footprint by occupation (2016) – UK



Source: ONS, Labour Force Survey, April to June 2016
Because no engineering SOC codes fall within major groups 4, 6, 7 and 9, these major groups have been omitted from this figure.

Personal characteristics of engineers/technicians within and outside engineering sectors

Gender diversity in the engineering profession remains a huge challenge across all sectors of the economy. Among all those working in engineering occupations within and outside the engineering sector, only 12.0% were female in 2016. Gender imbalances are thus even more pronounced among workers in engineering roles across the economy than workers in any role within the engineering sector (20.5%). Strikingly, proportionally more women were in an engineering role outside the engineering sector (where they make up 18.6% of the workforce) than within (9.3%).

Proportionally more women were in an engineering role outside the engineering sector (where they made up 18.6% of the total) than within (9.3%).

According to IET's 2017 Skills and Demand Industry survey, some employers are taking action to support more women in their organisations by offering terms and conditions which are attractive to women, such as flexible and part-time working. However, employers running specific initiatives to improve gender diversity are still a minority in the sector, with only 15% surveyed saying they make particular efforts to attract and retain women in their organisations.[7.20]

The underrepresentation of workers from ethnic minorities in engineering occupations is also as significant an issue as in the engineering sector, with only 8.3% of workers coming from ethnic minority backgrounds, compared with an average of 12.7% in non-engineering sectors. Ethnic minority workers are only slightly better represented in engineering occupations outside of engineering sectors, where they make up 10.0% of the workforce.

Again, while many employers would like to increase ethnic diversity in their workforce, the IET survey suggests only 9% of those businesses take particular actions to attract or recruit more BME (or LGBT) employees.[7.21]

7.20 IET. 'Skills & demand in industry survey', 2017.
7.21 Ibid.

Engineering: A woman's place?

Women account for just 9% of all engineers. Gender diversity within UK engineering remains one of the lowest of all the developed nations.

Even in today's more progressive society, many still perceive engineering to be a man's profession, with the culture of many companies reflecting this belief.

If we are to ever address the UK's engineering skills shortage, this outdated and ridiculous male-only perception of engineering needs to be laid to rest. We need to start finding ways to encourage and attract more women into the profession. Of those we do attract, we need to find ways to keep them, as nearly half of all female graduates leave the profession within a few years of gaining an engineering degree.

Over the last 20 years, there has been an improved understanding of what is needed to develop and retain female engineers in the workforce, such as mentoring programmes and flexible working arrangements. However, key to ensuring a diverse and motivated workforce, which works well and successfully delivers projects, is having a working environment that is conducive to this aim. By having a more representative workforce and ensuring that all people feel that they 'belong', you are likely to get more effective teams, more creative ideas, different perspectives and, ultimately, better solutions – and that will lead to improved business performance.

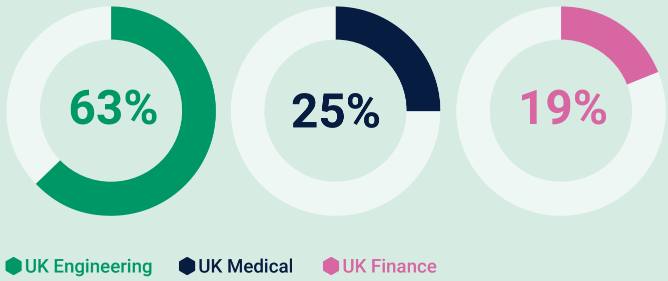
In 2017, the Institution of Mechanical Engineers published a study of research that was carried out to better understand the reasons why a large proportion of women leave the engineering profession early in their careers, and to propose what needs to be done to address this unacceptable level of attrition.

Institution of MECHANICAL ENGINEERS

Stephen Tetlow MBE CEng FIMechE,
Chief Executive, Institution of Mechanical Engineers

To establish the specific character of engineering, this unique study compared the experiences of female engineers with equivalent professionals in the medical sector, where 43% of doctors are women, and in the financial sector, where 46% of finance professionals are women. To provide an international perspective, the research also sought comparisons with female engineers in Germany, where women form a similar proportion of degree entrants but account for 15% of the engineering workforce.

Women who faced personal accounts of discrimination within the UK working sectors



The research showed personal experiences of discrimination were more prevalent in UK engineering than in other sectors, with 63% of female engineers personally experiencing unacceptable behaviour or comments (2.5 to 3 times more than that experienced by women in the financial or medical professions), while 20% stated they had witnessed similar actions directed at others.

Despite wishing to challenge 'workplace banter', female engineers describe being placed in an impossible position of either pretending they were not offended, or risking the accusation that they did not have a sense of humour. More than two thirds of UK female engineers reported feeling the need to adapt their personality or 'toughen up' to get by or get on.

Almost 40% of UK female engineers stated that they were simply not treated equally – not only by their managers, but also by their peers and even by the people they managed. Sixty-two per cent believed it was easier for men to progress within the engineering sector, which is marginally higher than in finance (60%), but significantly higher than in medicine (52%).

Employers should adopt a quality benchmark for retaining female engineers who are in the early to middle stages of their careers.

Perceptions of the factors that led to career advancement suggested that while quality of work or technical ability was seen as personally important to them, two-thirds of female engineers felt that career progression was determined through networks and social connections, and that it was in these areas they felt at a disadvantage.

The overarching narrative of the report is, however, that it is not female engineers themselves who need to change, but the environment in which they are operating. Many engineering companies have made real progress in this respect in recent years, but to reach the level of cultural change experienced in other sectors, it will require further effort across the entire profession.

Engineering can no longer afford to remain a sector in which women who join the profession are expected to change their personality in order to 'fit in'. Nor is it possible to rely solely on changing the attitudes of engineers to improve the working experience. Change must be driven from the top down, and to achieve real cultural shift, it is necessary for companies to become more accommodating and offer greater employment agility.

The cultural features of engineering in the UK are deeply ingrained and will take significant effort to change. The actions recommended, however, will significantly benefit the entire engineering sector. Companies will have the skills they require, employees will feel valued and fulfilled, and the nation will see a more productive, flexible and resilient workforce, which is essential for our economic future.

The report recommends 5 key areas for action:

- Employers should adopt a quality benchmark for retaining female engineers who are in the early to middle stages of their careers, building on existing best practice, such as the RICS Inclusive Employer Quality Mark
- Employers need to better emulate how the most effective companies address career 'flashpoints', such as returning to work after maternity leave, through implementing strategies that work for both female employees and the employer
- Improvements must include consultation with all employees annually (in confidence) on their views about the fairness of staff recognition, reward, professional support and work social activity
- The academic engineering community should carry out and publish a UK-wide study to characterise the experience of being a university engineering undergraduate
- A quality national careers programme in schools is needed both to encourage more women to pursue engineering and to contribute to reducing attrition in their early careers as part of the UK industrial strategy

"Senior people are more likely to circumvent me and approach my team directly – this never happens to male managers at the same grade."

It is clear that female engineers are working in an environment where many will experience or witness some form of discriminatory attitude or behaviour. To survive, they often feel compelled to compromise or adapt their personality to fit in with the prevailing culture. This unequal treatment can act as a major push factor for women considering leaving the engineering profession, and must be addressed if there is to be an improvement in the retention of female engineers. Though this experience is not the sole preserve of engineering, female engineers' experience of differential treatment occurs earlier than in other professions, often while still at university.

"While at university, another student told me that I shouldn't be an engineer because I am a woman and others suggested that I got better marks because I am female."

Well intended efforts to encourage greater participation of women in engineering through 'positive action' can have unintended negative consequences. The reality is that female engineers wish to be properly recognised for their accomplishments through positive feedback from managers and colleagues. While financial rewards are important, these engineers also seek informal recognition, promotion, seniority and additional responsibilities appropriate to their achievements – but not special treatment. Female engineers value having technically accomplished role models more than other professionals. While having a female mentor is seen as valuable, a shared professional interest is more highly valued.

The reasons why women choose to enter engineering employment and subsequently stay or leave are as complex and diverse as the people who make up the profession. There is no single action that will bring about the desired change, but the majority of the responsibility to achieve a significantly improved gender balance lies with the companies, including their management and their workforce, who need to provide a working environment that supports all employees to be productive, fulfilled and contented.

To download a copy of 'Stay or Go? The experience of female engineers in early career' visit the Institution of Mechanical Engineers website at imeche.org/reports

8 - Graduate destinations and recruitment

73% of UK domiciled first degree students who had studied engineering and technology full time found some form of employment

Employment rates into engineering occupations were higher among white or male graduates than their female or BME peers

Key points

This year, the government trialled its Teaching Excellence Framework (TEF), which includes the 'employability' of graduates as one of its assessment criteria. It is hoped this will contribute to addressing skills shortages, especially in high skilled STEM areas, where concerns have been expressed around some graduates not being sufficiently 'work ready'. The UK's decision to leave the EU threatens to exacerbate the skills gap further, and underscores the need for greater collaboration between industry and government to ensure talent and skills are secured and retained in the sector.

Employment prospects

Compared with other STEM subjects, more engineering and technology graduates tended to go overseas to find work. In fact, 18.3% of taught postgraduates went overseas – more than the all-subject average. These findings may reflect the fact that a higher than average proportion of engineering students are non UK domiciled.

In terms of finding full time employment, UK domiciled first degree graduates who had studied engineering and technology full time fared better than average in 2015 to 2016 (62.0% entered full time employment, compared with 56.1% of all graduates). Employment outcomes for full time UK domiciled engineering and technology postgraduates were better still: 63.5% of taught postgraduates and 80.7% of research postgraduates entered full time employment in 2015 to 2016.

Among UK domiciled engineering and technology graduates who had studied full time, broadly equal numbers of men and women entered full time employment after completing their first degree, although women were more likely to go on to postgraduate study. There were more pronounced variations by ethnicity: unemployment was consistently highest, and full time employment lowest, for BME engineering graduates.

Destinations

Out of full time UK domiciled engineering and technology graduates, those in civil engineering were most likely to enter an engineering occupation (75.8% did so). However, the majority engineering and technology graduates entered a relevant occupation (61.2%).

Notably, graduates who are white or male are more likely to secure engineering jobs in the sector, and BME graduates and women are less likely. Among engineering and technology graduates who found employment 6 months after graduation, 39.6% of BME and 35.7% of women were in roles that were neither engineering-related or within the sector. This compares to 27.9% of white and 29.6% of male engineering and technology graduates. These findings are concerning, at the very least indicating that women and BME graduates are 'leaking' from the pipeline. Further investigation is needed to look at whether these gender and ethnicity gaps come from engineering graduates' own choice of career direction or are down to factors in the occupational recruitment process.

Graduates in subjects other than engineering also form an important part of the engineering workforce supply chain. In fact, more than 70% of full time UK domiciled graduates who entered an engineering occupation did not have an engineering degree.

Prospects and salaries

Despite the uncertainty brought on by the EU Referendum in 2016, evidence suggests that the UK graduate recruitment market in 2017 is just that – a graduates' market. Employers stepped up their graduate vacancies, the number of paid work experience programmes increased, as did paid vacation internships.

Full time, UK domiciled graduates whose first degree was in engineering and technology achieved a higher starting salary than graduates in most other subjects: their starting salary (£25,607) was higher than the all-subject average (£21,719).

Across all levels of study, female engineering and technology graduates earned less than their male peers. The gender pay gap was widest among research postgraduates (8.4%) and smallest among first degree graduates (1.7%). However, analysis by discipline presents a more complex picture: in certain disciplines and particular levels of study, women earned more than men (for example, first degree graduates in electronic and electrical engineering).

Variances in starting salaries were less pronounced between white engineering and technology graduates and those of BME origin. However, this was not consistent across levels of study and ethnic groups. More detailed analysis could shed light on the extent to which these earning differentials are dependent on the occupation and the industry sector that graduates enter.

8.1 – Context

TEF and skills shortages in STEM: employment vs. employability

As detailed in **Chapter 6**, 2017 saw the passage of the Higher Education and Research Act. Among other things, this introduced the Teaching Excellence Framework (TEF), a government assessment of the quality of undergraduate teaching in universities and other higher education providers in England.

As part of its assessment framework, the TEF includes data from the Destination of Leavers from HE (DLHE) survey, which looks at student outcomes 6 months after graduating. TEF uses this data to link graduates' labour market destinations with the quality of university teaching. According to the government's white paper *Higher education: success as a knowledge economy,*[8.1] making this link aims to close the gap between skills shortages suffered by employers (especially in high skilled STEM areas), and the 20% or so of employed graduates who are in non-professional roles three and a half years after graduating. By making employability a specific criterion within the TEF framework, the government hopes that employers will be able to recruit graduates with the right skills, while students will be able to make more informed choices about which institutions and courses will maximise their employability. Trial results from the TEF were published in June 2017.

However, sector bodies such as the Higher Education Academy (HEA)[8.2] and the Higher Education Policy Institute (HEPI)[8.3] have expressed concern that the government's emphasis on destinations does not distinguish sufficiently between 'employment' and 'employability', and have questioned whether this approach will indeed help to address skills shortages in STEM sub-sectors in the future. Both note that the student outcome metrics included in the TEF only reflect labour market demand. Yet 'employability,' they argue, should capture the skills that enable graduates to 'get, keep and succeed in jobs they want – both now and in the future, as the economy shifts.'[8.4] If a graduate's destination is outside of the expected or relevant sector, it is not an indication of their lack of employability. They contend that a focus on destinations in the TEF can only tell us so much when addressing specific skills shortages such as those experienced in STEM sub-sectors.

The issue of employment versus employability has been a long-standing concern in the STEM sector, particularly in engineering. In recent years, the government has conducted at least two reviews into this problem. The Wakeham review (2016) took a broad view of STEM subjects with relatively weak employment outcomes, while the Shadbolt review (2016) looked specifically at computer sciences – a subject in which graduate employment outcomes are mixed. These reviews presented evidence of employers being dissatisfied with the level of graduates' 'soft' skills or 'work readiness'. They found that, to build genuine employability, graduates needed to have at least some work experience before entering the labour market.[8.5, 8.6] This underscores the importance of collaboration between industry and education to give students experiences of real life application of the subjects they are studying.

However, as Shadbolt notes, there is currently no coherent voice from employers expressing what they are looking for in a STEM graduate, and to maximise graduates' employability, understanding employers' needs is crucial. Some have argued that the government's commitment to increasing the quantity and quality of apprenticeships in the UK could be a way of closing the skills gap in STEM. They note that, despite an increase in the number of graduates over the past few decades, the number of graduates in highly-skilled roles has failed to follow suit.[8.7] In fact, many graduates now find themselves taking roles that would have been filled by non-graduates. Again, this has been linked to university degrees not being an indicator of work-readiness or 'commercial savviness'.

Conversely, analysis of UK online vacancy postings between 2012 and 2016 points towards the high employability of STEM graduates when it comes to non-STEM jobs, such as graphic design, business, management consultancy, and economics.[8.8] According to the research by the London School of Economics' Systematic Risk Centre, 35% of all jobs that were advertised as STEM were found to belong to non-STEM occupations, while 15% of all postings advertised as non-STEM occupations were in fact STEM jobs. Employers in non-STEM sectors appear to hire STEM graduates based on skills that they acquire during their STEM education, such as Microsoft C#, systems engineering, product development, data mining and modelling, and advanced statistics.

The TEF is a clear attempt by the government to prompt universities to do more to help their students get into sustainable work that closely matches their knowledge and skills. However, voices within the sector suggest that focussing on destinations and linking them to the quality of teaching may not be enough. They note that the government should also find ways of helping sectors with skills shortages to recognise the need to significantly increase the attractiveness of their work to students, particularly those coming to the end of their degrees. Finally, as Wakeham notes, more needs to be done to understand what exactly employers need and expect from STEM graduates. Achieving closer collaboration between STEM employers and higher education providers could be one way of identifying these needs, whilst giving graduates the opportunity to develop their 'work readiness' through work experience.

The graduate premium

Despite the rapid expansion of higher education participation over the past 3 decades, the graduate premium – that is, the economic benefit that those with a degree earn over their peers – has surprisingly remained relatively stable. Research by the Institute of Fiscal Studies (IFS) notes that the median wage differential between graduates and school leavers has remained at around 35% over the past 2 decades for 25 to 29 year olds.[8.9]

8.1 BIS. 'Higher education: success as a knowledge economy – white paper', May 2016.
8.2 HEA. 'Embedding employability in higher education for student success', July 2016.
8.3 HEPI. 'Tackling wicked issues: prestige and employment outcomes in the Teaching Excellence Framework', September 2016.
8.4 HEPI. 'Employability. Degrees of value', December 2015.
8.5 e.g. BIS. 'STEM degree provision and graduate employability: Wakeham review', May 2016.
8.6 BIS. 'Computer science degree accreditation: Shadbolt review', May 2016.
8.7 The Adecco Group. 'Closing the skills gap. Will apprenticeships deliver the workforce of tomorrow?' April 2017.
8.8 SRC. 'The STEM requirements of 'Non-STEM' jobs: evidence from UK online vacancy postings and implications for skills and knowledge shortages', May 2017.
8.9 IFS. 'The puzzle of graduate wages', August 2016.

Various reasons for this stability have been put forward. IFS suggest that the graduate premium may have persisted, despite an increased supply of graduates, because of changes in the way work is structured in organisations. A more highly educated workforce has allowed companies to become less hierarchical. In turn, this has increased both employee productivity and demand for graduates.

Another argument put forward by IFS is that while HE participation has risen exponentially, so too has the need for graduate skills due to technological advancements and globalisation. This supports the assertions made elsewhere in the IFS report and in much other research that STEM skills are critical for the continued growth of the UK economy.

Different roles attract different graduate premiums. Analysing the salaries of 2015 graduates who began graduate employment compared with non-graduate employment, the Complete University Guide calculated a professional premium. Strikingly, 3 of the 5 subjects with the highest professional premium were engineering-related: chemical engineering, general engineering, and aeronautical and manufacturing engineering.[8.10]

Variations in the 'graduate premium' are determined not only by subject choice, but also by universities attended. The Office for National Statistics' Labour Force Survey is a quarterly study of the employment circumstances of 100,000 individuals across the UK. Using data gathered since 2012, the student information website, bestcourse4me, has carried out an analysis of graduate earnings. It found that, by age 40, graduates from Russell Group universities earn almost £7,000 a year more on average than UK graduates from other HE institutions.[8.11]

Recent government figures also show that the graduate premium varies by gender.[8.12] Five years after leaving education, men were more likely to have a higher salary than women who graduated in the same subject in the same year. This was true for all subjects except English, where women were likely to earn more after 5 years. The difference in median pay was particularly striking in engineering and technology, where women earned on average £4,300 less than men 5 years from graduation. A previous report by the Trade Union Congress (TUC) also highlighted racial inequality in the graduate premium, with black graduates earning on average 23% less per hour than white graduates.[8.13]

While it is uncertain why the relative wage advantage has remained stable in a period of unprecedented growth in the supply of graduates, what is clear is that both graduate and non-graduate earnings have been falling in real terms since the mid-2000s. This reflects the finding discussed in **Chapter 9**: that the UK is the only advanced economy in which wages have contracted while the economy and employment has expanded. However, this expansion (and the corresponding downward pressure on wages) has begun to reduce over the last year. The Financial Times believes this is potentially a result of the EU referendum vote and the economy being close to full employment.[8.14]

Leaving the European Union: implications for the engineering graduate supply

The engineering sector already faces a skills gap. Changes to the freedom of movement of people from EU member states could make it even harder to find and retain talent and skills.

The Royal Academy of Engineering (RAEng) consulted over 400 businesses and individuals across the engineering sector on this issue. The resulting report lists access to skilled workers as a major area of concern for the future of engineering once the UK is outside of the EU, together with access to markets, and foreign investment and compliance with and ability to influence European standards and legislations that affect engineering companies.[8.15] It also notes that in academia, specifically, engineering and technology had proportionately more staff originating from the EU (15%) than across all subjects as a whole.

Among other recommendations, the RAEng called on government to make sure that talented EU students and academics have certainty about opportunities to study and work in the UK, and that UK students and academics are able to gain international experience, including in the EU.

However, some have argued that the UK's exit from the EU could pose opportunities. Engineering graduates might face less competition on the labour market with skilled candidates from abroad. And engineering businesses could find it easier to retain home-grown talent if British engineers don't have the same freedom to take positions in other EU countries.[8.16]

In these times of great political uncertainty, what remains clear is that change is imminent. Government, as well as businesses, need to be proactive to ensure that this change brings more opportunities to the sector than adversities.

8.2 – Overview of graduate destinations

This section provides an overview of first destinations of graduates by domicile, gender, ethnicity and level of study. It is based on the annual Higher Education Statistics Agency's (HESA) Destination of Leavers from Higher Education (DLHE) survey, which records the circumstances of UK and EU graduates an average of 6 months after they graduate. With a response rate of up to 80% of the relevant target population, these survey results are very robust, and comprise a key performance indicator for higher education institutions with regards to employment outcomes.

While there is some analysis by domicile, the majority of this chapter pertains to UK domiciled, full time graduates. This is to maintain consistency with previous reports. UK domiciled, full time graduates are a particularly robust sub-group of graduates to analyse, as most UK graduates will want to work in the UK. Part time students have been excluded on the basis that they are more likely to already have been employed either before or during their studies. Their employment rates and salaries may therefore not be reflective of first destinations.

8.10 The Complete University Guide. 'Subjects with the highest and lowest graduate premium', October 2016.
8.11 bestcourse4me. 'Analysis of the Labour Force Survey 'Institution Question', September 2016.
8.12 DfE. 'Graduate outcomes for all subjects by university', June 2017.
8.13 TUC. 'Black workers with degrees earn a quarter less than white counterparts, finds TUC', February 2016.
8.14 Financial Times. 'How wages fell in the UK while the economy grew', March 2017.
8.15 RaEng. 'Engineering a future outside the EU – securing the best outcome for the UK', October 2016.
8.16 The Engineer. 'Brexit Britain: the impact on UK businesses', January 2017.

First destinations by domicile and level of study

Figure 8.1 shows that 6 months after leaving university, UK domiciled graduates who studied full time were more likely to enter full time employment than their EU domiciled peers (57.5% compared with 52.3%). This was the case across all levels of study, with the gap most pronounced among first degree graduates (56.1% of UK domiciles compared with 40.9% of EU domiciles). In addition, a larger proportion of UK graduates entered part time employment than their EU domiciled peers (12.0% compared with 7.6%).

Figure 8.1 First destinations of full time leavers who graduated in the academic year 2015 to 16, by domicile and level of study – UK

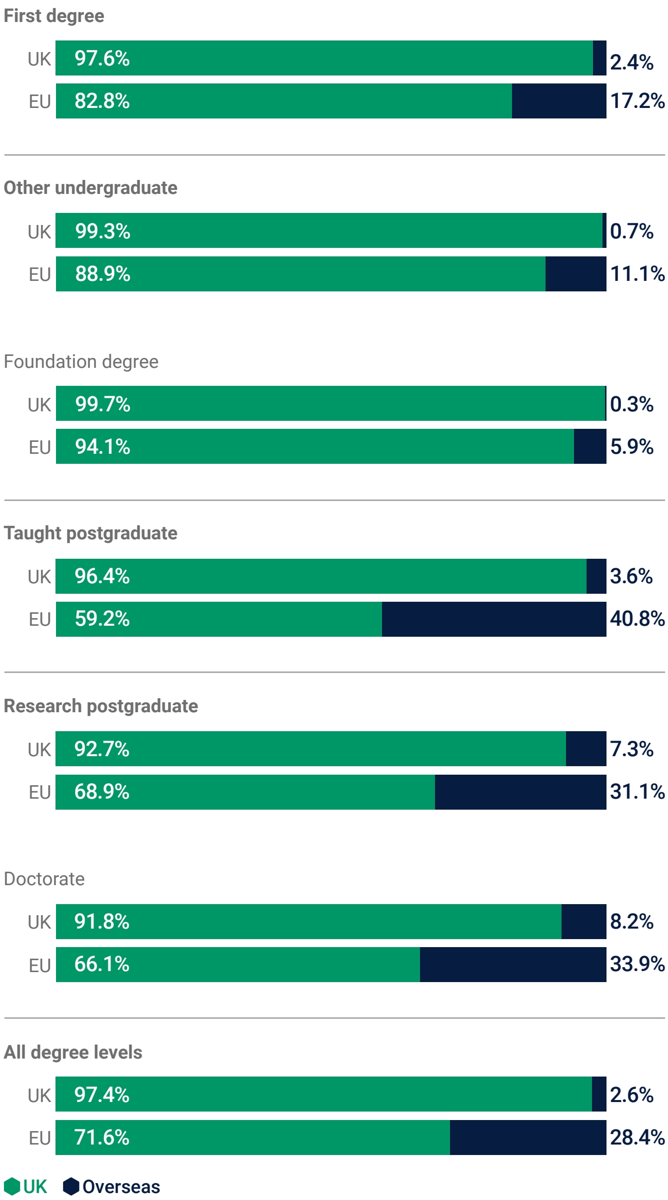
		UK	EU
First degree	Full time work	56.1%	40.9%
	Part time work	12.4%	6.7%
	Full time or part time study	16.4%	36.5%
	Work and further study	5.2%	6.2%
	Unemployed	5.4%	5.8%
	Other	4.4%	4.0%
	Total no.	229,805	10,920
Other undergraduate	Full time work	36.3%	23.1%
	Part time work	11.0%	6.4%
	Full time or part time study	33.1%	48.9%
	Work and further study	11.4%	11.7%
	Unemployed	4.5%	3.5%
	Other	3.8%	6.4%
	Total no.	20,125	515
Taught postgraduate	Full time work	72.1%	63.9%
	Part time work	10.6%	8.6%
	Full time or part time study	6.5%	11.6%
	Work and further study	2.8%	3.3%
	Unemployed	4.6%	8.4%
	Other	3.4%	4.3%
	Total no.	44,845	10,060
Research postgraduate	Full time work	68.6%	65.0%
	Part time work	9.2%	8.1%
	Full time or part time study	10.9%	14.0%
	Work and further study	3.2%	3.0%
	Unemployed	4.6%	7.2%
	Other	3.5%	2.7%
	Total no.	7,350	1,820
All degree levels	**Full time work**	**57.5%**	**52.3%**
	Part time work	**12.0%**	**7.6%**
	Full time or part time study	**15.9%**	**24.3%**
	Work and further study	**5.2%**	**4.8%**
	Unemployed	**5.2%**	**7.0%**
	Other	**4.2%**	**4.1%**
	Total no.	**302,125**	**23,320**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this table with numbers and by foundation degrees and doctorates, see Figure 8.1 in our Excel resource.

Compared with UK leavers, those from the EU were more likely to remain in full time or part time study (24.3% compared with 15.9%) and to be unemployed (7.0% compared with 5.2%). In terms of unemployment, this difference in proportions was most pronounced among postgraduates: 3.8 percentage points among taught postgraduates and 3.4 percentage points among doctorates.

Perhaps understandably, EU domiciled leavers were more likely to find employment overseas 6 months after graduating than UK domiciled leavers (**Figure 8.2**). However, for both UK and EU domiciled leavers, the proportion finding employment overseas increased with degree level. Among UK domiciled leavers, for example, 3.6% of taught and 7.3% of research postgraduates were employed abroad, compared with just 2.4% of first degree and 0.7% of other undergraduates.

Figure 8.2 Full time leavers in UK/overseas employment 6 months after graduating in 2015 to 16, by level of study and domicile – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this chart with numbers, see Figure 8.2 in our Excel resource.

First destinations by gender and level of study

As **Figure 8.3** shows, among UK domiciled students who had studied full time, slightly more women than men entered full time employment 6 months after graduation (58.6% compared with 56.0%). A larger proportion of female graduates also entered part time work (12.5% compared with 11.3%), while male graduates were more likely to be unemployed (6.8% compared with 4.1%).

Figure 8.3 First destinations of full time UK domiciled leavers who graduated in 2015 to 2016, by gender and level of study – UK

		Male	Female
First degree	Full time work	54.8%	57.1%
	Part time work	11.8%	12.9%
	Full time or part time study	17.4%	15.7%
	Work and further study	4.6%	5.6%
	Unemployed	7.0%	4.3%
	Other	4.3%	4.5%
	Total no.	96,620	133,145
Other undergraduate	Full time work	36.6%	36.1%
	Part time work	9.9%	11.8%
	Full time or part time study	34.7%	31.8%
	Work and further study	9.7%	12.7%
	Unemployed	6.2%	3.1%
	Other	3.0%	4.4%
	Total no.	9,040	11,080
Taught postgraduate	Full time work	69.4%	73.9%
	Part time work	9.8%	11.1%
	Full time or part time study	8.0%	5.4%
	Work and further study	3.0%	2.7%
	Unemployed	6.2%	3.5%
	Other	3.5%	3.4%
	Total no.	17,570	27,265
Research postgraduate	Full time work	70.2%	66.9%
	Part time work	7.4%	11.2%
	Full time or part time study	11.1%	10.8%
	Work and further study	3.0%	3.3%
	Unemployed	5.3%	3.7%
	Other	3.0%	4.1%
	Total no.	3,855	3,495
All degree levels	**Full time work**	**56.0%**	**58.6%**
	Part time work	**11.3%**	**12.5%**
	Full time or part time study	**17.2%**	**15.0%**
	Work and further study	**4.7%**	**5.5%**
	Unemployed	**6.8%**	**4.1%**
	Other	**4.1%**	**4.3%**
	Total no.	**127,085**	**174,985**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this table with numbers and by disability status, see **Figure 8.3** and **8.4a** in our Excel resource.

There were also gender differences by level of study. The gender gap between those who entered full time employment was widest among those who graduated with a taught postgraduate degree (4.5 percentage points), while in terms of unemployment rates it was widest among other undergraduates (3.1 percentage points).

First destinations by ethnicity and level of study

All ethnicity data in this chapter is presented for UK domiciled students only. This is because it is only compulsory to collect ethnicity data for UK domiciled students, although those students can choose not to disclose. Non-white groups have been aggregated into a single black and minority (BME) category. While there are limitations to this approach, it is a useful way to identify high level patterns of difference in relation to ethnicity.

Figure 8.4 shows that among full time UK domiciled graduates, a larger proportion of white leavers than BME leavers entered full time employment (59.0% compared with 51.9%). This was the case across all levels of study. At the same time, larger proportions of BME graduates stayed in higher education to pursue full time or part time study (17.5% compared with 15.5% of white leavers). This was especially the case for those who graduated with a foundation or other undergraduate degree.

Among full time UK domiciled graduates, BME leavers had higher unemployment rates than white leavers, with the overall gap at 3.4 percentage points. A closer look at levels of study reveals that this gap was even wider among doctorates (5.1 percentage points), research postgraduates (4.3%) and taught postgraduates (4.5 percentage points).

8.3 – First destinations by level of study

This section presents analysis of engineering and technology graduate destinations from the DLHE, organised by levels of study.

Engineering and technology is one out of 19 subject areas within **the Joint Academic Coding System (JACS)** used by HESA to classify academic subjects. This is the highest level by which subjects can be analysed; they can be further disaggregated by discipline, each of which has a 2-digit code. The engineering and technology subject area comprises the disciplines H0-J9. To highlight possible differences within engineering and technology and assist those who may have a specific interest in a particular discipline, some tables in this chapter present engineering and technology data at this 2-digit level.

Where possible, the chapter also compares the destinations of engineering and technology graduates with those in other subject areas.

Since total numbers of respondents in certain groups in engineering and technology disciplines fell below HESA's reporting threshold of 22.5, the results for some response options have been suppressed.

Figure 8.4 First destinations of full time UK domiciled leavers who graduated in 2015 to 2016, by ethnicity and level of study – UK

		White	BME
First degree	Full time work	57.5%	51.2%
	Part time work	12.1%	13.7%
	Full time or part time study	16.1%	17.6%
	Work and further study	5.2%	5.0%
	Unemployed	4.7%	8.0%
	Other	4.4%	4.5%
	Total no.	180,505	47,760
Other undergraduate	Full time work	38.5%	27.5%
	Part time work	10.7%	11.8%
	Full time or part time study	31.4%	39.8%
	Work and further study	11.9%	9.5%
	Unemployed	4.0%	6.3%
	Other	3.5%	5.1%
	Total no.	15,855	4,040
Taught postgraduate	Full time work	73.7%	65.8%
	Part time work	10.5%	11.1%
	Full time or part time study	6.3%	6.8%
	Work and further study	2.9%	2.4%
	Unemployed	3.7%	8.2%
	Other	2.9%	5.7%
	Total no.	35,825	8,305
Research Postgraduate	Full time work	69.0%	66.4%
	Part time work	9.6%	7.0%
	Full time or part time study	10.9%	11.4%
	Work and further study	3.3%	2.3%
	Unemployed	4.0%	8.3%
	Other	3.2%	4.5%
	Total no.	6,105	1,025
All degree levels	**Full time work**	**59.0%**	**51.9%**
	Part time work	**11.7%**	**13.1%**
	Full time or part time study	**15.5%**	**17.5%**
	Work and further study	**5.3%**	**4.9%**
	Unemployed	**4.5%**	**7.9%**
	Other	**4.1%**	**4.7%**
	Total no.	**238,295**	**61,130**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this table by more detailed ethnic group or by disability status, see **Figure 8.4-8.4a** in our Excel resource.

First degree leavers

Out of all STEM subjects, engineering and technology had the third-largest proportion of first degree graduates who found employment overseas, alongside veterinary science (both at 4.0%). (The largest was architecture, building and planning, at 4.2%). This compares with 3.0% of first degree graduates overall moving overseas 6 months after leaving university (see **Figure 8.5**). The higher than average rate of overseas employment among engineering and technology first degree graduates from the EU may reflect the fact that the subject also has a higher than average proportion of EU students, as detailed in **Chapter 6**. In fact, first degree engineering and technology graduates from the EU, who left in 2015 to 2016 were nearly 10 times more likely to find employment overseas than those from the UK (20.7% compared with 2.6%).

First degree engineering and technology graduates from the EU were nearly 10 times more likely to find employment overseas than those from the UK (20.7% compared with 2.6%).

Figure 8.5 Full time first degree leavers who graduated in 2015 to 2016, by country of employment and subject area – UK

STEM subjects	UK %	Overseas %	Total no.
Agriculture and related subjects	95.9%	4.1%	2,020
Architecture, building and planning	95.8%	4.2%	4,185
Biological sciences	97.6%	2.4%	27,935
Computer science	97.2%	2.8%	9,545
Engineering and technology	96.0%	4.0%	12,840
UK domiciled	*97.4%*	*2.6%*	*11,845*
EU domiciled	*79.3%*	*20.7%*	*995*
Mathematical sciences	97.3%	2.7%	5,165
Medicine and dentistry	99.4%	0.6%	7,015
Physical sciences	97.2%	2.8%	12,160
Subjects allied to medicine	99.0%	1.0%	27,405
Veterinary science	96.0%	4.0%	605
Total STEM	**97.7%**	**2.3%**	**108,875**
Total non STEM	**96.4%**	**3.6%**	**131,850**
All subjects	**97.0%**	**3.0%**	**240,730**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this table with numbers and figures for non STEM subjects, see **Figure 8.5** in our Excel resource.

Figure 8.6 Full time UK domiciled first degree leavers who graduated in 2015 to 2016, by leaving destination and subject area – UK

STEM subjects	Full time work %	Part time work %	Full time or part time study %	Work and further study %	Unemployed %	Other %	Total no.
Agriculture & related subjects	58.1%	12.1%	12.8%	5.2%	4.8%	7.0%	1,975
Architecture, building & planning	70.1%	7.2%	8.5%	4.7%	5.8%	3.8%	3,855
Biological sciences	41.4%	15.0%	26.1%	7.6%	5.1%	4.8%	26,875
Computer science	63.7%	10.1%	10.4%	2.5%	9.7%	3.5%	8,920
Engineering & technology (H0-J9)	62.0%	8.0%	15.4%	2.8%	7.5%	4.4%	11,840
Engineering disciplines (H0-H9)	62.3%	7.2%	15.5%	2.8%	7.5%	4.4%	10,810
(H0) Broadly-based programmes	*–*	*–*	*–*	*–*	*–*	*–*	*5*
(H1) General engineering	*61.0%*	*6.7%*	*17.8%*	*2.4%*	*6.2%*	*5.9%*	*760*
(H2) Civil engineering	*68.2%*	*4.6%*	*15.0%*	*2.9%*	*5.5%*	*3.9%*	*1,915*
(H3) Mechanical engineering	*63.5%*	*7.2%*	*14.4%*	*2.7%*	*8.1%*	*4.1%*	*3,465*
(H4) Aerospace engineering	*56.2%*	*9.3%*	*18.1%*	*3.0%*	*8.5%*	*5.0%*	*1,080*
(H5) Naval architecture	*69.7%*	*6.1%*	*6.1%*	*3.0%*	*3.0%*	*12.1%*	*35*
(H6) Electronic & electrical engineering	*61.8%*	*9.6%*	*14.0%*	*2.6%*	*8.3%*	*3.7%*	*1,955*
(H7) Production & manufacturing engineering	*66.2%*	*8.5%*	*9.7%*	*3.2%*	*7.1%*	*5.3%*	*435*
(H8) Chemical, process & energy engineering	*54.7%*	*6.3%*	*22.0%*	*3.1%*	*8.5%*	*5.4%*	*1,145*
(H9) Others in engineering	*–*	*–*	*–*	*–*	*–*	*–*	*15*
Technology disciplines (J1-J9)	58.2%	14.9%	12.5%	2.4%	6.7%	3.8%	1,040
(J1) Minerals technology	*67.9%*	*0.0%*	*3.6%*	*7.1%*	*14.3%*	*7.1%*	*30*
(J2) Metallurgy	*–*	*–*	*–*	*–*	*–*	*–*	*10*
(J3) Ceramics & glass	*–*	*–*	*–*	*–*	*–*	*–*	*15*
(J4) Polymers & textiles	*69.7%*	*10.1%*	*7.1%*	*1.0%*	*8.1%*	*4.0%*	*100*
(J5) Materials technology not otherwise specified	*47.6%*	*4.8%*	*32.1%*	*4.8%*	*8.3%*	*2.4%*	*170*
(J6) Maritime technology	*65.0%*	*2.5%*	*16.3%*	*1.3%*	*7.5%*	*7.5%*	*80*
(J7) Biotechnology	*45.5%*	*6.1%*	*30.3%*	*6.1%*	*3.0%*	*9.1%*	*35*
(J9) Others in technology	*60.3%*	*20.5%*	*7.0%*	*2.8%*	*5.8%*	*3.5%*	*600*
Mathematical sciences	49.9%	7.8%	23.6%	5.8%	7.4%	5.4%	4,955
Medicine & dentistry	91.9%	0.8%	4.8%	1.6%	0.3%	0.6%	6,875
Physical sciences	43.7%	9.8%	29.9%	4.8%	6.8%	5.1%	11,745
Subjects allied to medicine	77.9%	7.1%	7.4%	3.2%	2.1%	2.2%	26,640
Veterinary science	92.4%	1.9%	1.3%	1.0%	1.7%	1.7%	595
Total STEM	**60.7%**	**9.5%**	**16.6%**	**4.5%**	**5.0%**	**3.8%**	**104,275**
Total non STEM	**52.4%**	**14.8%**	**16.3%**	**5.7%**	**5.8%**	**5.0%**	**125,530**
All subjects	**56.1%**	**12.4%**	**16.4%**	**5.2%**	**5.4%**	**4.4%**	**229,800**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with numbers and figures for non STEM subjects, please see **Figure 8.6** in our Excel resource.

62.0% of engineering and technology first degree graduates entered full time employment, compared with 56.1% of first degree graduates overall.

Figure 8.6 provides a comparison of leaving destinations for full time UK domiciled first degree graduates by subject area and select engineering disciplines.

Overall, 72.8% of UK domiciled first degree students who had studied engineering and technology full time found some form of employment – be it full time, part time, or a combination of work and further study – six months after graduating. This compares to 73.7% across graduates from all subjects. Notably, however, an above average proportion of engineering and technology graduates entered full time employment (62.0%), with fewer than the all-subject average entering part time work (8.0%) or work and further study (2.8%). The unemployment rate among engineering and technology graduates was also slightly higher (7.5%) than for all graduates combined (5.4%).

UK domiciled engineering and technology graduates who had studied full time were less likely to enter full time employment (62.0%) than those who graduated in medicine and dentistry (91.9%), veterinary subjects (92.4%), subjects allied to medicine (77.9%), architecture, building and planning (70.1%), and computer science (63.7%). However, a higher proportion did so compared with physical science and biological science graduates. Less than half of physical science and biological science graduates entered full time employment, although a higher proportion progressed onto full time or part time study.

Of all the engineering disciplines, naval architecture and civil engineering graduates were the most successful at finding full time employment (69.7% and 68.2% of full time UK domiciled first degree graduates). In comparison, those in chemical, process and energy engineering, aerospace engineering and general engineering were most likely to continue onto full time or part time study.

Other undergraduate leavers

Among full time UK domiciled students who had studied engineering and technology at the 'other' undergraduate level, 54.4% were in employment of some kind 6 months after graduating (full time, part time, or work and further study) compared with 58.6% of those across all subjects (**Figure 8.8**).

Almost all 'other' undergraduate graduates employed 6 months after graduating (99.0%) were working in the UK. This proportion was only slightly smaller for engineering and technology graduates (98.2%), graduates in architecture, planning and building (96.8%), physical sciences (98.7%) and agriculture and related subjects (98.7%) (see **Figure 8.7**). This is likely to reflect the domicile composition of engineering and technology students studying on 'other' undergraduate programmes.

Figure 8.7 Other full time undergraduate leavers who graduated in 2015 to 2016, by country of employment and subject area (all and foundation degrees) – UK

	Other undergraduate leavers			Foundation degree		
STEM subjects	**UK %**	**Overseas %**	**Total no.**	***UK %***	***Overseas %***	***Total no.***
Agriculture and related subjects	98.7%	1.3%	865	*99.2%*	*0.8%*	*615*
Architecture, building and planning	96.8%	3.2%	535	*100.0%*	*0.0%*	*25*
Biological sciences	99.1%	0.9%	1,705	*100.0%*	*0.0%*	*650*
Computer science	99.4%	0.6%	1,065	*100.0%*	*0.0%*	*235*
Engineering and technology	98.2%	1.8%	1,275	*98.9%*	*1.1%*	*470*
UK domiciled	*98.7%*	*1.3%*	*1,230*	*99.1%*	*0.9%*	*455*
EU domiciled	*86.7%*	*13.3%*	*45*	–	–	*10*
Mathematical sciences	99.3%	0.7%	150	–	–	*0*
Medicine and dentistry	100.0%	–	165	–	–	*0*
Physical sciences	98.7%	1.3%	460	*100.0%*	*0.0%*	*95*
Subjects allied to medicine	99.5%	0.5%	3,040	*99.4%*	*0.6%*	*900*
Veterinary science	–	–	0	–	–	*0*
Total STEM	**99.0%**	**1.0%**	**9,255**	***99.4%***	***0.6%***	***2,990***
Total non STEM	**99.0%**	**1.0%**	**11,390**	***99.7%***	***0.3%***	***3,820***
All subjects	**99.0%**	**1.0%**	**20,650**	***99.6%***	***0.4%***	***6,815***

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with numbers and figures for non STEM subjects, see **Figure 8.7** in our Excel resource.

Figure 8.8 Other full time UK domiciled undergraduate leavers who graduated in 2015 to 2016, by destination and subject area (all and foundation degree leavers) – UK

	Other undergraduate leavers						
STEM subjects	**Full time work %**	**Part time work %**	**Full time or part time study %**	**Work and further study %**	**Unemployed %**	**Other %**	**Total no.**
Agriculture & related subjects	25.4%	9.2%	47.5%	12.8%	2.6%	2.6%	850
Architecture, building & planning	42.1%	6.6%	29.2%	12.7%	5.6%	3.8%	495
Biological sciences	26.8%	13.8%	39.3%	11.1%	4.9%	4.1%	1,665
Computer science	24.1%	10.9%	41.0%	8.4%	12.0%	3.7%	1,040
Engineering & technology (H0-J9)	37.6%	6.1%	36.5%	10.7%	6.4%	2.7%	1,230
Engineering disciplines (H0-H9)	38.4%	6.1%	36.4%	11.1%	6.6%	2.5%	990
(H0) Broadly based programmes	–	–	–	–	–	–	*0*
(H1) General engineering	*42.1%*	*5.3%*	*35.1%*	*12.3%*	*5.3%*	*1.8%*	*115*
(H2) Civil engineering	*29.7%*	*6.3%*	*45.0%*	*12.6%*	*4.5%*	*3.6%*	*110*
(H3) Mechanical engineering	*30.1%*	*8.3%*	*43.7%*	*7.9%*	*7.9%*	*2.2%*	*230*
(H4) Aerospace engineering	*65.4%*	*1.9%*	*23.4%*	*2.3%*	*4.2%*	*3.3%*	*215*
(H5) Naval architecture	–	–	–	–	–	–	*0*
(H6) Electronic & electrical engineering	*26.1%*	*6.3%*	*38.6%*	*19.1%*	*7.0%*	*3.3%*	*270*
(H7) Production & manufacturing engineering	–	–	–	–	–	–	*20*
(H8) Chemical, process & energy engineering	*33.3%*	*14.8%*	*37.0%*	*0.0%*	*14.8%*	*3.7%*	*25*
(H9) Others in engineering	–	–	–	–	–	–	*0*
Technology disciplines (J1-J9)	34.0%	6.0%	38.0%	14.0%	8.0%	2.0%	250
(J1) Minerals technology	–	–	–	–	–	–	*0*
(J2) Metallurgy	–	–	–	–	–	–	*0*
(J3) Ceramics and glass	–	–	–	–	–	–	*0*
(J4) Polymers and textiles	–	–	–	–	–	–	*10*
(J5) Materials technology not otherwise specified	–	–	–	–	–	–	*20*
(J6) Maritime technology	*68.7%*	*1.5%*	*14.9%*	*6.0%*	*4.5%*	*3.0%*	*65*
(J7) Biotechnology	–	–	–	–	–	–	*0*
(J9) Others in technology	*20.0%*	*10.3%*	*45.2%*	*11.6%*	*8.4%*	*3.2%*	*155*
Mathematical sciences	37.1%	11.9%	21.0%	4.9%	16.1%	9.1%	145
Medicine & dentistry	25.0%	17.1%	51.2%	2.4%	2.4%	1.8%	165
Physical sciences	25.6%	13.6%	38.1%	6.5%	10.5%	5.8%	450
Subjects allied to medicine	59.0%	8.8%	19.7%	6.8%	2.2%	3.5%	3,015
Veterinary science	–	–	–	–	–	–	0
Total STEM	**39.5%**	**10.0%**	**32.7%**	**9.1%**	**5.2%**	**3.6%**	**9,045**
Total non STEM	**33.7%**	**11.8%**	**33.5%**	**13.3%**	**3.9%**	**3.9%**	**11,080**
All subjects	**36.3%**	**10.9%**	**33.1%**	**11.4%**	**4.5%**	**3.8%**	**20,130**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with student numbers and figures for non STEM subjects, see **Figure 8.8** in our Excel resource.

Foundation degree						
Full time work %	Part time work %	Full time or part time study %	Work and further study %	Unemployed %	Other %	Total no.
22.3%	6.6%	53.2%	13.8%	1.8%	2.3%	600
22.2%	3.7%	63.0%	7.4%	3.7%	0.0%	25
15.3%	8.4%	52.7%	19.7%	2.3%	1.6%	640
9.9%	4.7%	66.8%	12.1%	6.0%	0.4%	230
47.3%	2.9%	36.0%	10.3%	2.4%	1.1%	455
50.8%	0.0%	33.3%	9.5%	1.6%	1.6%	315
–	–	–	–	–	–	0
61.8%	0.0%	17.6%	20.6%	0.0%	0.0%	35
41.9%	0.0%	41.9%	16.1%	0.0%	0.0%	30
15.8%	2.6%	59.2%	18.4%	3.9%	0.0%	75
74.3%	1.4%	21.5%	0.7%	0.0%	2.1%	145
–	–	–	–	–	–	0
40.0%	3.3%	30.0%	23.3%	0.0%	3.3%	30
–	–	–	–	–	–	0
–	–	–	–	–	–	0
–	–	–	–	–	–	0
34.5%	6.9%	41.4%	6.9%	3.4%	0.0%	145
–	–	–	–	–	–	0
–	–	–	–	–	–	0
–	–	–	–	–	–	0
–	–	–	–	–	–	0
–	–	–	–	–	–	10
69.4%	2.0%	18.4%	4.1%	4.1%	2.0%	50
–	–	–	–	–	–	0
16.3%	9.3%	52.3%	14.0%	7.0%	1.2%	85
–	–	–	–	–	–	0
–	–	–	–	–	–	0
5.2%	5.2%	80.2%	4.2%	4.2%	1.0%	95
58.9%	6.9%	22.6%	9.6%	1.1%	0.9%	900
–	–	–	–	–	–	0
34.2%	**6.3%**	**43.1%**	**12.8%**	**2.2%**	**1.4%**	**2,950**
16.1%	**8.1%**	**46.9%**	**24.4%**	**2.0%**	**2.6%**	**3,760**
24.0%	**7.3%**	**45.2%**	**19.3%**	**2.1%**	**2.0%**	**6,710**

As noted in **Chapter 6**, engineering and technology qualifiers at this level are predominantly UK domiciled (85.5%). Notably, full time UK domiciled other undergraduate engineering and technology leavers had very different destinations compared with those who graduated with a first degree. Over a third (37.6%) of engineering and technology 'other' leavers entered full time employment, slightly higher than the average across all subjects combined (36.3%). However, this was almost half the rate of those with a first degree (62.0%). Their unemployment rate (6.4%) was also lower compared with first degree graduates (7.5%), and markedly lower compared with other undergraduate leavers in mathematical sciences (16.1%), computer science (12.0%) and physical sciences (10.5%) (see **Figure 8.8**).

Analysis by engineering discipline shows that 'other' undergraduate leavers who graduated in aerospace engineering were most likely to enter full time employment (65.4%), while those who graduated in civil engineering (45.0%), mechanical engineering (43.7%), and electronic and electrical engineering (38.6%) were most likely to pursue full time or part time study.

Taught postgraduate leavers

Among full time UK domiciled taught postgraduates who had studied engineering and technology, 74.9% were in employment of some kind 6 months after graduating (full time, part time, or work and further study) (**Figure 8.10**).

A larger proportion of taught postgraduates were in employment overseas after graduation than undergraduates. Across all subjects combined, this proportion was 10.4% (see **Figure 8.9**). Proportionally, more taught postgraduates in engineering and technology taught postgraduates found employment overseas than any other STEM subject (18.3%). As might be expected, this trend was particularly high among EU domiciled engineering and technology graduates, 38.7% of whom moved overseas for employment.

The higher than average rate of overseas employment among engineering and technology taught postgraduates may reflect the fact that the subject also has a higher than average proportion of international students. As detailed in **Chapter 6**, 14.8% of taught postgraduate qualifiers in engineering and technology were from the EU and a further 59.0% were from outside of the EU. It should be noted, however, that qualifiers outside of the EU are not covered by the DLHE survey.

Employment outcomes were even more promising for taught postgraduates in engineering and technology than for those at undergraduate level, with 74.9% in employment of some kind six months after graduating.

Figure 8.9 Full time taught postgraduate leavers who graduated in 2015 to 2016, by country of employment and subject area – UK

STEM subjects	UK %	Overseas %	Total no.
Agriculture and related subjects	91.7%	8.3%	300
Architecture, building and planning	92.0%	8.0%	1,615
Biological sciences	93.4%	6.6%	4,085
Computer science	86.2%	13.8%	1,410
Engineering and technology	81.7%	18.3%	2,365
UK domiciled	*95.0%*	*5.0%*	*1,435*
EU domiciled	*61.3%*	*38.7%*	*935*
Mathematical sciences	86.9%	13.1%	585
Medicine and dentistry	93.4%	6.6%	1,055
Physical sciences	91.3%	8.7%	1,750
Subjects allied to medicine	96.4%	3.6%	3,020
Veterinary science	92.9%	7.1%	40
Total STEM	**91.0%**	**9.0%**	**16,225**
Total non STEM	**89.0%**	**11.0%**	**38,680**
All subjects	**89.6%**	**10.4%**	**54,915**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this table with numbers and figures for non STEM subjects, see **Figure 8.9** in our Excel resource.

Employment outcomes were even more promising for full time UK domiciled taught postgraduates in engineering and technology than those at undergraduate level. For engineering and technology, 63.5% of UK domiciled full time taught postgraduates who graduated in the academic year starting 2015 were in full time employment 6 months later (see **Figure 8.10**). Full time employment was particularly high for those who graduated in civil engineering (73.5%). Full time UK domiciled taught postgraduates who graduated in chemical, process and energy engineering (14.0%), general engineering (12.9%) and technology disciplines (12.8%) were most likely to continue onto full time or part time study than those in other engineering disciplines.

Strikingly, however, at 11.4% the unemployment rate for full time, UK domiciled taught postgraduate leavers in engineering and technology was higher than for any other subject area, and more than double the rate observed for leavers overall. Unemployment was particularly high among those who had graduated from electronic and electrical engineering (14.9%) and production and manufacturing engineering (13.9%).

Figure 8.10 Full time UK domiciled taught postgraduate leavers who graduated in 2015 to 2016, by destination and subject area – UK

STEM subjects	Full time work %	Part time work %	Full time or part time study %	Work and further study %	Unemployed %	Other %	Total no.
Agriculture & related subjects	61.0%	16.7%	7.7%	2.4%	7.7%	4.5%	245
Architecture, building & planning	78.7%	6.1%	2.1%	4.7%	5.2%	3.3%	1,320
Biological sciences	55.2%	16.4%	14.3%	4.4%	5.9%	3.7%	3,550
Computer science	69.0%	6.9%	9.2%	2.1%	8.6%	4.3%	1,005
Engineering & technology (H0-J9)	63.5%	9.8%	8.9%	1.6%	11.4%	4.9%	1,435
Engineering disciplines (H0-H9)	64.1%	9.7%	8.5%	1.2%	10.9%	5.2%	1,240
(H0) Broadly-based programmes	–	–	–	–	–	–	*0*
(H1) General engineering	*60.3%*	*10.3%*	*12.9%*	*0.9%*	*9.5%*	*6.0%*	*115*
(H2) Civil engineering	*73.5%*	*7.1%*	*5.7%*	*0.9%*	*9.5%*	*3.3%*	*335*
(H3) Mechanical engineering	*66.2%*	*6.0%*	*8.8%*	*1.4%*	*11.6%*	*6.0%*	*215*
(H4) Aerospace engineering	*59.6%*	*14.0%*	*7.9%*	*1.8%*	*12.3%*	*4.4%*	*115*
(H5) Naval architecture	–	–	–	–	–	–	*10*
(H6) Electronic & electrical engineering	*53.7%*	*12.6%*	*10.9%*	*3.4%*	*14.9%*	*4.6%*	*175*
(H7) Production & manufacturing engineering	*65.3%*	*8.3%*	*1.4%*	*1.4%*	*13.9%*	*9.7%*	*70*
(H8) Chemical, process & energy engineering	*55.4%*	*13.4%*	*14.0%*	*1.3%*	*10.2%*	*5.7%*	*155*
(H9) Others in engineering	*70.6%*	*5.9%*	*2.0%*	*2.0%*	*13.7%*	*5.9%*	*50*
Technology disciplines (J1-J9)	61.5%	10.3%	12.8%	0.0%	10.3%	0.0%	195
(J1) Minerals technology	*90.3%*	*3.2%*	*3.2%*	*0.0%*	*0.0%*	*3.2%*	*30*
(J2) Metallurgy	–	–	–	–	–	–	*5*
(J3) Ceramics and glass	–	–	–	–	–	–	*0*
(J4) Polymers & textiles	–	–	–	–	–	–	*5*
(J5) Materials technology not otherwise specified	–	–	–	–	–	–	*10*
(J6) Maritime technology	–	–	–	–	–	–	*20*
(J7) Biotechnology	*57.5%*	*13.8%*	*12.5%*	*2.5%*	*12.5%*	*1.3%*	*80*
(J9) Others in technology	*65.1%*	*11.6%*	*9.3%*	*2.3%*	*11.6%*	*0.0%*	*45*
Mathematical sciences	52.6%	4.3%	28.6%	3.5%	6.7%	4.3%	370
Medicine & dentistry	64.3%	7.4%	17.1%	2.1%	3.7%	5.3%	885
Physical sciences	61.4%	11.0%	12.3%	1.7%	8.4%	5.1%	1,450
Subjects allied to medicine	72.8%	11.2%	7.8%	2.1%	3.4%	2.6%	2,730
Veterinary science	66.7%	11.1%	13.9%	2.8%	2.8%	2.8%	35
Total STEM	**64.6%**	**11.2%**	**11.0%**	**2.9%**	**6.3%**	**3.9%**	**13,025**
Total non STEM	**75.2%**	**10.3%**	**4.6%**	**2.8%**	**3.8%**	**3.3%**	**31,815**
All subjects	**72.1%**	**10.6%**	**6.5%**	**2.8%**	**4.6%**	**3.5%**	**44,850**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with numbers and figures for non STEM subjects, please see **Figure 8.10** in our Excel resource.

Case study – Apprenticeships to drive diversity

Helen Eleftheriou, Early Careers Resourcing Manager, Rolls-Royce

Rolls-Royce has a strong commitment to apprentice and graduate recruitment and to further developing employee skills through a wide range of world-class training programmes.

Rolls-Royce offers a wide range of early career programmes, including advanced apprenticeships, degree apprenticeships, specialist training schemes, undergraduate internships and graduate development programmes. In 2017, we recruited 312 graduates and 339 apprentices onto our global programmes.

Rolls-Royce has a particular focus on increasing the diversity of the company's talent pipeline. We are recruiting from groups under-represented in the engineering sector, particularly women and those from disadvantaged backgrounds and minority ethnic groups. We believe it is important to increase the number of diverse people at all levels of the company, as well as attracting more women and people from diverse backgrounds into STEM careers. To help us track progress, we have agreed global gender and inclusiveness targets and other key indicators, as well as introducing a Global Diversity and Inclusion Council to help drive change.

The company sponsors the Female Undergraduate of the Year award. We work with schools and universities to encourage female students and make sure that they have every opportunity to maximise their potential – not only in engineering and manufacturing, but across all subjects and skills. We work to inspire young women considering their next steps and future careers.

Rolls-Royce provides over 600 work experience placements each year across our UK sites. We aim to attract a broad range of people, to help create a more diverse pipeline into Rolls-Royce and the wider world of engineering. We encourage applications from all under-represented groups, including black, Asian and minority ethnic, and we strive for a 50:50 gender balance.

Research postgraduate leavers

Across all subjects, the proportion of research postgraduates who found employment overseas was 12.0%. Among doctorates, this proportion was even larger at 13.5%, and particularly large among those who were EU domiciled (31.9%) (see **Figure 8.11**).

Unlike in the case of taught postgraduates, the proportion of engineering and technology research postgraduates who went overseas was only slightly larger than the across-subject average (13.5%, and 14.2% among doctorates specifically). The STEM subjects with the largest proportions of research postgraduates who went overseas were mathematical sciences (20.2%) and architecture, building and planning (18.2%). It should be remembered, however, that 45.8% of qualifiers at research postgraduate level in engineering and technology were from outside of the EU, and therefore not covered by the DLHE survey.

UK domiciled research postgraduates who had studied engineering and technology full time had very good employment outcomes. 86.0% were in employment of some kind 6 months after graduating (full time, part time, or work and further study) compared with 81.0% of those across all subjects. Moreover, as **Figure 8.12** shows, they had a higher full time employment rate than any other STEM subject, at 80.7%.

Figure 8.13 adds to this positive story, showing that among full time UK domiciled students who had studied engineering and technology, research postgraduates were more successful at finding full time employment than taught postgraduates, first degree graduates and other undergraduates. Those with a doctorate in engineering and technology were most successful of all, with an 85.0% full time employment rate (**Figure 8.12**).

When analysed by engineering disciplines, mechanical engineering (84.2%), civil engineering, and chemical, process and energy engineering (each 82.5%) had the largest proportions of research postgraduates in full time employment.

The unemployment rate among engineering and technology research postgraduates was similar to that of all subjects combined (4.8% compared with 4.6%). The exceptions to this were aerospace engineering (7.7%) and chemical, process and energy engineering (8.2%).

Figure 8.11 Full-time research postgraduate leavers who graduated in 2015 to 2016, by country of employment and subject area (all and doctorates) – UK

	Research postgraduates			Doctorates		
STEM subjects	**UK %**	**Overseas %**	**Total no.**	***UK %***	***Overseas %***	***Total no.***
Agriculture and related subjects	92.0%	8.0%	75	*90.5%*	*9.5%*	*65*
Architecture, building and planning	81.8%	18.2%	90	*80.5%*	*19.5%*	*75*
Biological sciences	89.9%	10.1%	1,635	*88.7%*	*11.3%*	*1,340*
Computer science	87.4%	12.6%	360	*86.1%*	*13.9%*	*275*
Engineering and technology	86.5%	13.5%	1,020	*85.8%*	*14.2%*	*930*
UK domiciled	*92.3%*	*7.7%*	*755*	*91.9%*	*8.1%*	*695*
EU domiciled	*70.0%*	*30.0%*	*265*	*68.1%*	*31.9%*	*235*
Mathematical sciences	79.8%	20.2%	285	*78.3%*	*21.7%*	*265*
Medicine and dentistry	93.6%	6.4%	930	*92.0%*	*8.0%*	*690*
Physical sciences	86.1%	13.9%	1,555	*84.8%*	*15.2%*	*1,340*
Subjects allied to medicine	90.7%	9.3%	675	*88.1%*	*11.9%*	*455*
Veterinary science	90.2%	9.8%	40	*89.5%*	*10.5%*	*40*
Total STEM	**88.4%**	**11.6%**	**6,665**	***86.9%***	***13.1%***	***5,470***
Total non STEM	**86.7%**	**13.3%**	**2,510**	***85.6%***	***14.4%***	***1,955***
All subjects	**88.0%**	**12.0%**	**9,175**	***86.5%***	***13.5%***	***7,425***

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this table with numbers, see **Figure 8.11** in our Excel resource.

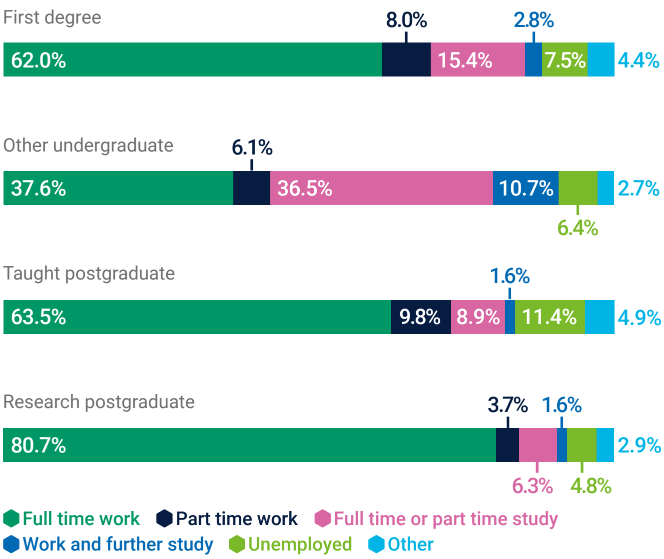
Figure 8.12 Full time UK domiciled research postgraduate leavers who graduated in 2015 to 2016, by destination and subject area (all and doctorates) – UK

	Research postgraduates						
STEM subjects	Full time work %	Part time work %	Full time or part time study %	Work and further study %	Unemployed %	Other %	Total no.
Agriculture & related subjects	73.8%	4.6%	6.2%	3.1%	6.2%	6.2%	65
Architecture, building & planning	75.0%	9.4%	6.3%	1.6%	6.3%	1.6%	65
Biological sciences	72.4%	6.0%	11.3%	3.6%	3.5%	3.2%	1,390
Computer science	66.9%	6.5%	15.7%	4.0%	4.4%	2.4%	250
Engineering & technology (H0-J9)	80.7%	3.7%	6.3%	1.6%	4.8%	2.9%	755
Engineering disciplines (H0-H9)	79.2%	3.8%	7.7%	1.5%	5.4%	3.1%	650
(H0) Broadly-based programmes	*–*	*–*	*–*	*–*	*–*	*–*	*0*
(H1) General engineering	*73.8%*	*3.8%*	*11.9%*	*2.5%*	*3.1%*	*5.0%*	*160*
(H2) Civil engineering	*82.5%*	*6.2%*	*3.1%*	*2.1%*	*4.1%*	*2.1%*	*95*
(H3) Mechanical engineering	*84.2%*	*3.0%*	*4.0%*	*3.0%*	*4.0%*	*2.0%*	*100*
(H4) Aerospace engineering	*66.7%*	*5.1%*	*20.5%*	*0.0%*	*7.7%*	*0.0%*	*40*
(H5) Naval architecture	*–*	*–*	*–*	*–*	*–*	*–*	*0*
(H6) Electronic & electrical engineering	*81.8%*	*5.6%*	*4.9%*	*0.7%*	*4.2%*	*2.8%*	*145*
(H7) Production & manufacturing engineering	*–*	*–*	*–*	*–*	*–*	*–*	*15*
(H8) Chemical, process & energy engineering	*82.5%*	*2.1%*	*3.1%*	*1.0%*	*8.2%*	*3.1%*	*95*
(H9) Others in engineering	*–*	*–*	*–*	*–*	*–*	*–*	*0*
Technology disciplines (J1-J9)	86.4%	0.0%	4.5%	0.0%	4.5%	0.0%	110
(J1) Minerals technology	*–*	*–*	*–*	*–*	*–*	*–*	*0*
(J2) Metallurgy	*100.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*30*
(J3) Ceramics & glass	*–*	*–*	*–*	*–*	*–*	*–*	*0*
(J4) Polymers & textiles	*–*	*–*	*–*	*–*	*–*	*–*	*5*
(J5) Materials technology not otherwise specified	*80.0%*	*0.0%*	*6.0%*	*2.0%*	*12.0%*	*0.0%*	*50*
(J6) Maritime technology	*–*	*–*	*–*	*–*	*–*	*–*	*5*
(J7) Biotechnology	*–*	*–*	*–*	*–*	*–*	*–*	*5*
(J9) Others in technology	*–*	*–*	*–*	*–*	*–*	*–*	*15*
Mathematical sciences	74.8%	4.8%	8.1%	2.4%	7.1%	2.9%	210
Medicine & dentistry	74.8%	3.5%	11.4%	4.2%	3.1%	3.0%	805
Physical sciences	73.0%	4.6%	10.8%	1.9%	6.5%	3.1%	1,275
Subjects allied to medicine	64.0%	7.2%	18.4%	3.2%	4.1%	3.1%	555
Veterinary science	61.5%	10.3%	12.8%	10.3%	0.0%	5.1%	40
Total STEM	**73.0%**	**5.1%**	**11.2%**	**3.0%**	**4.6%**	**3.1%**	**5,405**
Total non STEM	**56.3%**	**20.5%**	**10.2%**	**3.7%**	**4.6%**	**4.8%**	**1,950**
All subjects	**68.6%**	**9.2%**	**10.9%**	**3.2%**	**4.6%**	**3.5%**	**7,355**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with numbers and figures for non STEM subjects, see **Figure 8.12** in our Excel resource.

Doctorates						
Full time work %	Part time work %	Full time or part time study %	Work and further study %	Unemployed %	Other %	Total no.
78.6%	5.4%	3.6%	1.8%	7.1%	3.6%	55
78.9%	10.5%	0.0%	1.8%	7.0%	1.8%	55
80.2%	7.0%	3.3%	3.3%	3.2%	2.9%	1,260
80.0%	7.2%	2.6%	3.6%	3.6%	3.1%	195
85.0%	3.6%	1.9%	1.4%	4.9%	3.2%	695
84.9%	4.2%	2.5%	1.7%	5.0%	3.4%	595
–	–	–	–	–	–	0
80.4%	4.2%	3.5%	2.8%	3.5%	5.6%	145
88.8%	3.4%	0.0%	1.1%	4.5%	2.2%	90
85.3%	3.2%	3.2%	3.2%	3.2%	2.1%	95
82.8%	6.9%	3.4%	0.0%	6.9%	0.0%	30
–	–	–	–	–	–	0
86.9%	6.2%	0.0%	0.0%	3.8%	3.1%	130
–	–	–	–	–	–	10
82.5%	2.1%	3.1%	1.0%	8.2%	3.1%	95
–	–	–	–	–	–	0
94.7%	0.0%	0.0%	0.0%	5.3%	0.0%	95
–	–	–	–	–	–	0
100.0%	–	–	–	–	–	30
–	–	–	–	–	–	0
–	–	–	..	–	–	0
84.4%	0.0%	0.0%	2.2%	13.3%	0.0%	45
–	–	–	–	–	–	5
–	–	–	–	–	–	5
–	–	–	–	–	–	10
77.7%	5.1%	4.1%	2.5%	7.6%	3.0%	195
81.1%	4.1%	4.6%	3.9%	3.1%	3.3%	615
80.7%	4.2%	3.2%	2.0%	7.0%	3.0%	1,100
79.1%	6.5%	5.1%	3.0%	4.1%	2.2%	370
66.7%	8.3%	8.3%	11.1%	0.0%	5.6%	35
80.9%	**5.3%**	**3.4%**	**2.8%**	**4.7%**	**3.0%**	**4,575**
62.4%	**23.1%**	**2.2%**	**2.7%**	**4.9%**	**4.6%**	**1,515**
76.2%	**9.7%**	**3.1%**	**2.8%**	**4.7%**	**3.4%**	**6,095**

Figure 8.13 Full time UK domiciled engineering and technology leavers who graduated in 2015 to 2016, by leaving destination and subject area – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this chart with numbers and by engineering and technology dicipline, see **Figure 8.13** in our Excel resource.

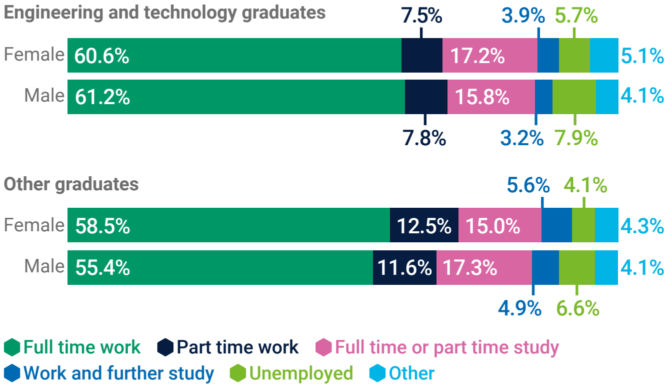
Variations by gender and ethnicity

Figure 8.14 shows that among full time UK domiciled engineering and technology graduates, outcomes for men and women were broadly similar. While a slightly larger proportion of male graduates entered full time employment than female graduates (61.2% compared with 60.6%), a larger proportion of female graduates entered either full time or part time study or work and further study (21.1% compared with 19.0%). This reflects our findings in **Chapter 6** that women in engineering and technology were more likely to pursue postgraduate study than their male peers.

There were, however, small differences in the unemployment rates between genders, with male graduates slightly more likely to be unemployed compared with their female peers (7.9% compared with 5.7%).

There were marked differences in destinations between white leavers and BME leavers, with a much larger proportion of white engineering and technology graduates entering full time employment (65.6%) than those of ethnic minority background (48.6%).

Figure 8.14 Full time UK domiciled leavers who graduated in 2015 to 2016, by gender and destination – UK



Source: HESA, Destinations of Leavers Survey 2015/16
To view this chart with numbers and by engineering and technology dicipline, see **Figure 8.14** in our Excel resource.

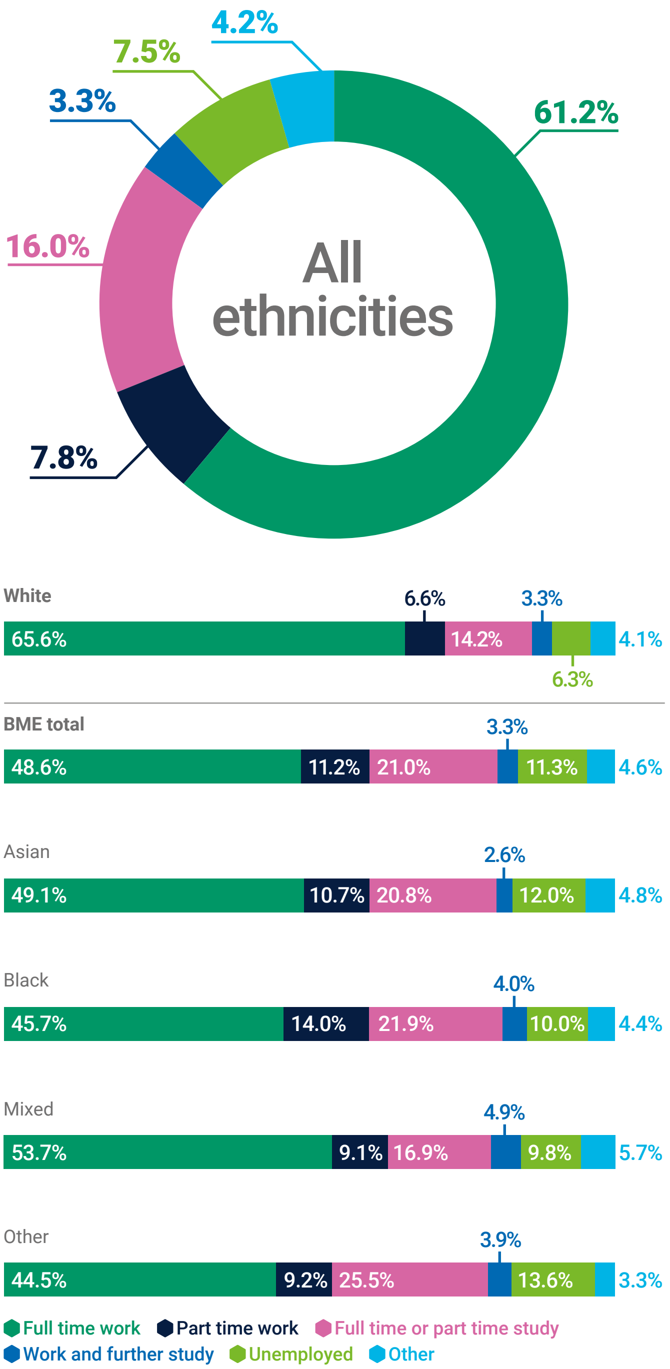
For full time UK domiciled graduates in subjects other than engineering and technology, the situation was reversed, with a larger proportion of women than men entering full time employment, and a larger proportion of male graduates who entering full time or part time study. However, unemployment continued to be more prevalent among male graduates than female graduates.

Figure 8.15 shows UK domiciled engineering and technology graduates who studied full time and graduated in the academic year starting 2015, by ethnic background. As can be seen, there were marked differences between white leavers and BME leavers, with a much larger proportion of white engineering and technology graduates entering full time employment (65.6%) than those of ethnic minority background (48.6%). At nearly at 20 percentage point difference, this gap was particularly large between white and black graduates.

At the same time, almost twice as many BME engineering and technology graduates than white graduates went into part time work. The same held true for unemployment, which was almost twice as high among BME leavers (11.3%) than white leavers (6.3%).

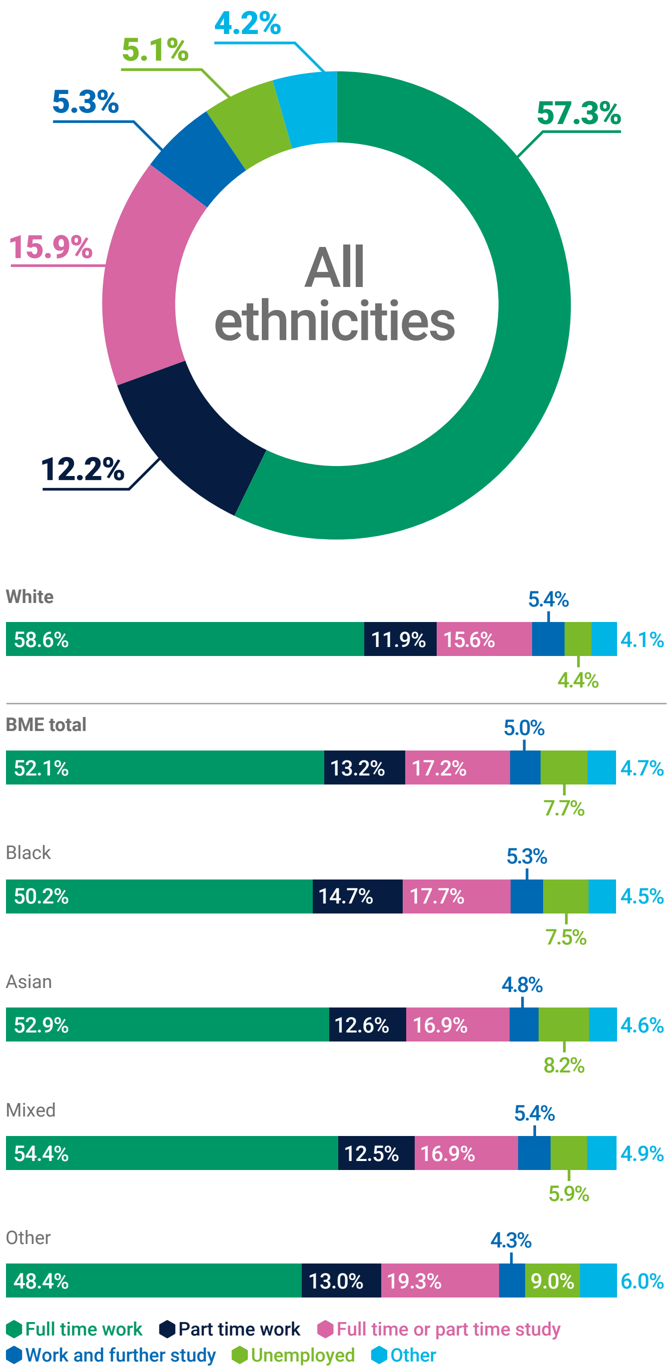
Although this trend can be observed among UK domiciled leavers of different ethnicities who studied full-time in general, these differences are more pronounced among engineering and technology graduates. Across all subjects other than engineering and technology, there was a 6.5 percentage point difference in the proportions of white and BME graduates who entered full time employment (see **Figure 8.16**). Among engineering and technology graduates, the difference was much larger at 17.0 percentage points (**Figure 8.15**). Similarly, the difference in the unemployment rate between white and BME graduates was greater for engineering and technology graduates (5.0 percentage points) than for graduates in other subjects (3.3 percentage points).

Figure 8.15 Full time UK domiciled engineering and technology leavers who graduated in 2015 to 2016, by destination and ethnicity – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this chart with numbers and by engineering and technology dicipline, see **Figure 8.15** in our Excel resource.

Figure 8.16 Full time UK domiciled graduates of subjects other than engineering and technology who graduated in 2015 to 2016, by destination and ethnicity – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this chart with numbers and by engineering and technology dicipline, see **Figure 8.16** in our Excel resource.

Even after controlling for other factors expected to affect employment outcomes, ethnicity remained a significant factor in determining employment outcomes, particularly for engineering roles.

This corresponds with research conducted by the Careers Research and Advisory Centre (CRAC) on behalf of the Royal Academy of Engineering (RAEng) in 2016, which found stark differences in employment outcomes between engineering graduates of white and minority ethnic origin both 6 months and 40 months after graduation. The difference was particularly striking with regards to unemployment: 40 months after graduation, 6.9% of BME engineering graduates were unemployed while only 1.5% of their white counterparts were. While outcomes for graduates in other subjects followed this general trend, differences were smaller, with 1.9% of white graduates unemployed compared with 4.8% BME graduates.[8.17] Even after controlling for other factors expected to affect employment outcomes, such as degree class, prior attainment and mission group of university attended, ethnicity remained a significant factor in determining employment outcomes, particularly for engineering roles.

The reasons for this are not fully understood, although there is evidence to suggest that several factors are at play:

- students from BME backgrounds may not always have as much social capital to draw on as their white counterparts.[8.18]
- graduate recruitment is often targeted at universities with lower proportions of BME students[8.19]
- recruitment practices are often vulnerable to unconscious bias[8.20]

Follow-up research by CRAC on behalf of the RAEng is currently underway to understand recruitment processes within engineering firms, and whether these may, in part, explain weaker employment outcomes among BME graduates.

Employment outcomes differed by engineering discipline, with more than three quarters of full time UK domiciled graduates in civil engineering and minerals technology working in engineering, compared with just 16.3% in biotechnology.

8.4 – Occupations entered

This section presents data on how many DLHE survey respondents who graduated in the academic year 2015 to 2016 entered engineering and non-engineering occupations. The analysis is based on Engineering UK's engineering footprint using the Standard Occupational Classification (SOC).

Engineering and technology graduates

Overall, 61.2% of full time UK domiciled engineering and technology students who found employment 6 months after graduating worked in an engineering occupation.

Of those employed 6 months after graduating, higher rates of EU domiciled engineering and technology graduates entered engineering occupations than those from the UK (**Figure 8.17**). This difference was particularly pronounced at the taught postgraduate level, where 67.7% were working in engineering occupations 6 months after graduating, compared with 58.8% of those who were UK domiciled.

Employment outcomes differed by engineering discipline, with more than three quarters of full time UK domiciled graduates in civil engineering and minerals technology working in engineering, compared with just 16.3% in biotechnology (**Figure 8.18**). Perhaps surprisingly, around two in five graduates in general engineering, aerospace engineering, and production and manufacturing engineering were in non-engineering-related occupations 6 months after graduation.

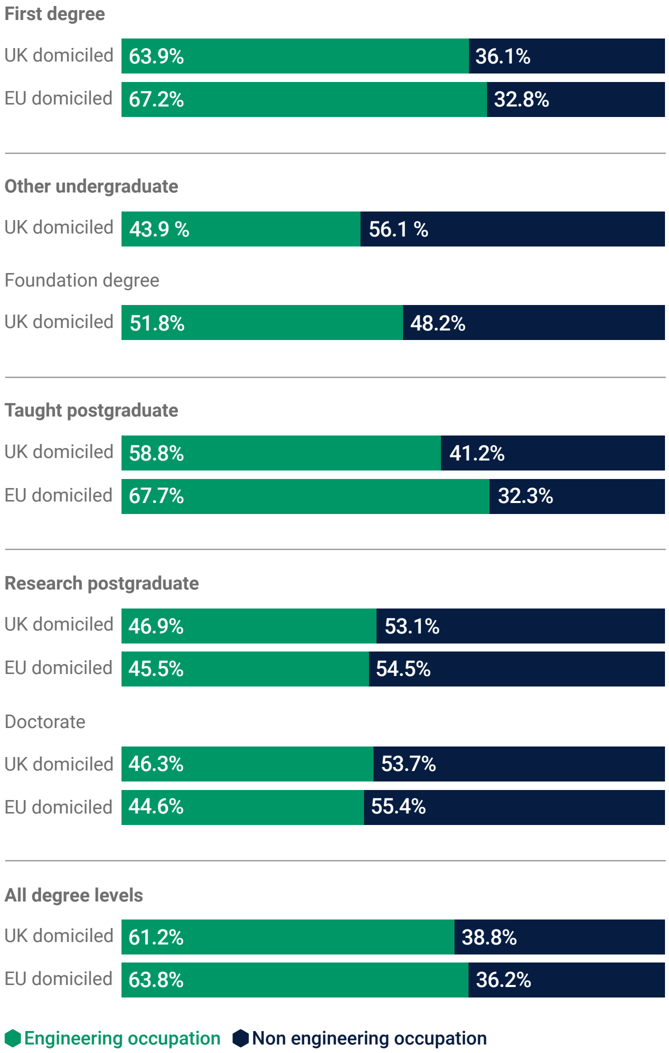
Variations by gender and ethnicity

Among UK domiciled engineering and technology graduates who had studied full time, similar proportions of male and female graduates found full time employment. Notably, however, differing proportions went into engineering occupations. **Figure 8.19** shows that, at every level of study, larger proportions of male graduates entered engineering occupations, with an overall gender gap of 8.1 percentage points. The gap was most pronounced among taught and research postgraduates. 61.0% of male engineering and technology taught postgraduates worked in an engineering occupation 6 months after graduation, compared with 49.8% of their female peers – an 11.2 percentage point difference. For research postgraduates, this difference was even wider, at 51.2% men and just 34.5% women (a 16.7 percentage point difference).

There was also a clear ethnic disparity among full time UK domiciled graduates. A considerably higher proportion of white than BME engineering and technology leavers entered engineering occupations 6 months after graduation. Across all disciplines, 63.3% of white engineering and technology graduates were in an engineering occupation, compared with 54.3% of leavers of BME origin (**Figure 8.20**). These differences were particularly pronounced among first degree graduates and other undergraduates.

8.17 RaEng. 'Employment outcomes of engineering graduates: key factors and diversity characteristics', 2016.
8.18 JRF and H. Metcalf et al. 'How place influences employment outcomes for ethnic minorities', May 2014.
8.19 Social Mobility & Child Poverty Commission. 'A qualitative evaluation of non-educational barriers to the elite professions', June 2015.
8.20 Perspectives and G. Beattie. 'Policy and Practice in Higher Education, Volume 16, Issue 1: Higher education: advancing equality in challenging times. Possible unconscious bias in recruitment and promotion and the need to promote equality', December 2011.

Figure 8.17 Full time engineering and technology leavers who found employment within 6 months of graduating in 2015 to 2016, by level of study, domicile and occupation – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
Proportions for EU domiciled other undergraduates and those studying foundation degrees have been suppressed due to small numbers (of between 0 and 22.5 inclusive)
To view this chart with numbers and split by core/related engineering occupations, see **Figure 8.17** in our Excel resource.

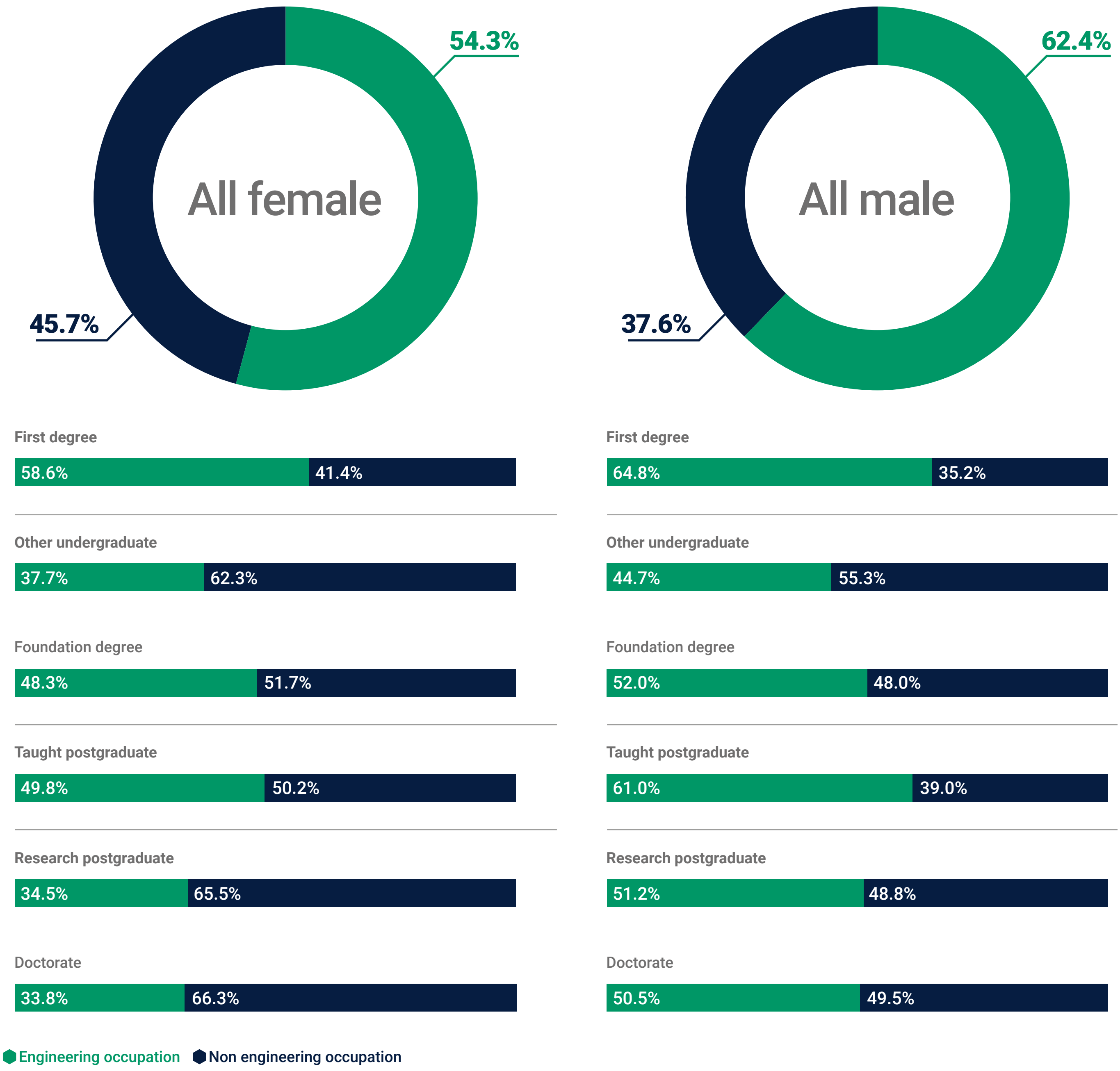
Among engineering and technology leavers, the rate entering an engineering occupation is higher among white or male graduates than their BME or female counterparts.

Figure 8.18 Full time UK domiciled employed engineering and technology leavers who graduated in 2015 to 2016, by principal subject and occupation – UK

	Engineering occupation %	Non engineering occupation %	Total no.
Engineering disciplines (H0-H9)	65.1%	34.9%	9,895
(H0) Broadly-based programmes	*–*	*–*	*5*
(H1) General engineering	*58.1%*	*41.9%*	*820*
(H2) Civil engineering	*75.8%*	*24.2%*	*1,870*
(H3) Mechanical engineering	*68.8%*	*31.2%*	*2,905*
(H4) Aerospace engineering	*58.6%*	*41.4%*	*1,010*
(H5) Naval architecture	*63.9%*	*36.1%*	*35*
(H6) Electronic & electrical engineering	*62.6%*	*37.4%*	*1,835*
(H7) Production & manufacturing engineering	*59.6%*	*40.4%*	*420*
(H8) Chemical, process & energy engineering	*52.8%*	*47.2%*	*945*
(H9) Others in engineering	*69.6%*	*30.4%*	*55*
Technology disciplines (J1-J9)	27.3%	72.7%	1,155
(J1) Minerals technology	*72.5%*	*27.5%*	*50*
(J2) Metallurgy	*57.1%*	*42.9%*	*40*
(J3) Ceramics & glass	*–*	*–*	*15*
(J4) Polymers & textiles	*30.3%*	*69.7%*	*90*
(J5) Materials technology not otherwise specified	*50.0%*	*50.0%*	*145*
(J6) Maritime technology	*31.7%*	*68.3%*	*125*
(J7) Biotechnology	*16.3%*	*83.8%*	*80*
(J9) Others in technology	*16.1%*	*83.9%*	*610*
All engineering and technology (H0-J9)	**61.2%**	**38.8%**	**11,050**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table with numbers, see **Figure 8.18** in our Excel resource.

Figure 8.19 Full time UK domiciled engineering and technology leavers who found employment within 6 months of graduating in 2015 to 16, by level of study, gender and occupation – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015 to 2016.
To view this chart with numbers, see **Figure 8.19** in our Excel resource.

Figure 8.20 Full time UK domiciled engineering and technology leavers who found employment within 6 months of graduating in 2015 to 16, by level of study, ethnicity and occupation – UK

Engineering occupation Non engineering occupation

Source: HESA, Destinations of Leavers from Higher Education Survey 2015 to 2016.
Proportions for those studying foundation degrees from BME backgrounds have been suppressed due to small numbers (of between 0 and 22.5 inclusive).
To view this chart with numbers or by disability status, see **Figure 8.20** and **8.20a** in our Excel resource.

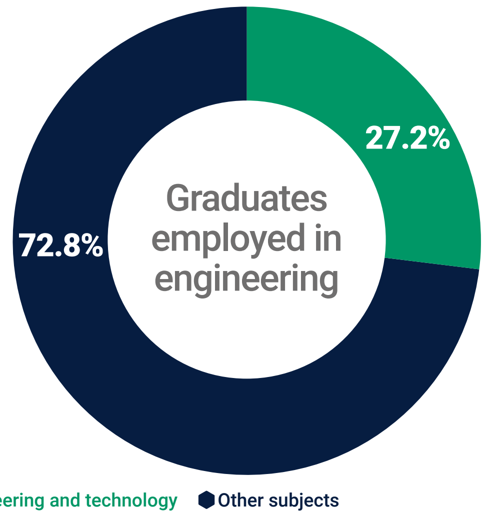
These findings are concerning, at the very least indicating that women and BME graduates are 'leaking' from the pipeline. Further investigation is needed to look at whether these gender and ethnicity gaps come from engineering graduates' own choice of career direction or are down to factors in the occupational recruitment process.

Non engineering and technology graduates

While a detailed analysis of occupations of graduates in subjects other than engineering and technology is beyond the scope of this report, it is important to note that these graduates also form an important element of the engineering workforce supply chain.

Figure 8.21 shows that out of all full time UK domiciled graduates who entered an engineering occupation 6 months after graduation, only 27.2% came from the engineering and technology subject grouping. This means that more than 7 in 10 of full time UK domiciled graduates who entered an engineering occupation did not have an engineering degree. The contribution of these other graduates to the potential supply of graduate-level skills in the engineering labour force is considered in **Chapter 10**.

Figure 8.21 Full time UK domiciled graduates in engineering occupations 6 months after graduating in 2015 to 16 by subject – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16

In particular, it is worth highlighting the significant contribution to the engineering workforce made by graduates from computer science and architecture, building, and planning, with rates of 63.2% and 73.9%, respectively, entering an engineering occupation (**Figure 8.22**). In fact, larger proportions of full time UK domiciled graduates from these disciplines entered engineering occupations than those from engineering and technology 61.2% (**Figure 8.17**).

Nineteen per cent of physical sciences graduates and 14.0% of mathematical sciences graduates were in an engineering occupation 6 months after graduation, which shows how well broader STEM skills transfer to engineering. A small but significant number (11.9%) of creative arts and design graduates also entered engineering occupations.

Figure 8.22 Full time UK domiciled non engineering and technology graduates in employment in 2015 to 16, by subject area and occupation – UK

	Engineering occupation %	Non engineering occupation %	Total no.
Agriculture and related subjects	11.1%	88.8%	2,155
Architecture, building and planning	73.9%	26.1%	4,710
Biological sciences	3.8%	96.2%	21,995
Business and administrative studies	5.4%	94.6%	24,320
Combined	3.8%	95.0%	260
Computer science	63.2%	36.8%	8,240
Creative arts and design	11.9%	88.1%	22,905
Education	0.4%	99.6%	27,285
Historical and philosophical studies	3.3%	96.7%	8,260
Languages	2.4%	97.5%	10,430
Law	2.2%	97.8%	7,155
Mass communications and documentation	3.9%	96.1%	6,240
Mathematical sciences	14.0%	86.0%	3,650
Medicine and dentistry	0.6%	99.4%	7,885
Physical sciences	19.0%	81.0%	9,195
Social studies	3.0%	97.0%	21,385
Subjects allied to medicine	1.0%	99.0%	28,595
Veterinary science	0.8%	99.5%	630
All non engineering and technology subjects	**8.4%**	**91.6%**	**215,290**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this table with numbers and split by core/related engineering occupations, see **Figure 8.22** in our Excel resource.

Six months after graduating, 16.4% of engineering and technology graduates became mechanical engineers and 15.7% civil engineers, making these the two most common engineering occupations.

Most popular engineering occupations

Figure 8.23 shows the top 10 occupations entered 6 months after graduation by UK domiciled engineering and technology graduates who had studied full time. 16.4% of engineering graduates became mechanical engineers and 15.7% civil engineers, making these the two most common engineering occupations.

While it may seem concerning that 10.6% graduates went into sales and retail (10.6%), this is not necessarily evidence of graduate under-employment. The DLHE survey is conducted around 6 months after graduation and there is evidence that a growing number of new graduates defer choices about their long-term career until some time after they have graduated. The employment they enter immediately after graduation may well be temporary.

In non engineering occupations, 2.8% worked as management consultants and business analysts, and 2.6% entered the financial sector as analysts and advisers.

Figure 8.23 Top 10 engineering and non engineering occupations entered by full time UK domiciled engineering and technology leavers 6 months after graduating in 2015 to 16 – UK

Engineering occupations	No.	%
Mechanical engineers	1,105	16.4%
Civil engineers	1,065	15.7%
Engineering professionals n.e.c.	915	13.5%
Design and development engineers	850	12.6%
Production and process engineers	435	6.4%
Programmers and software development professionals	310	4.6%
Electrical engineers	250	3.7%
Engineering technicians	210	3.1%
Electronics engineers	175	2.6%
Information technology and telecommunications professionals n.e.c.	170	2.5%

Non engineering occupations	No.	%
Sales and retail assistants	455	10.6%
Photographers, audio-visual and broadcasting equipment operators	195	4.5%
University researchers, unspecified discipline	175	4.1%
Business and related associate professionals n.e.c.	175	4.1%
Bar staff	160	3.8%
Management consultants and business analysts	120	2.8%
Finance and investment analysts and advisers	110	2.6%
Officers in armed forces	105	2.4%
Business sales executives	90	2.1%
Business and financial project management professionals	85	2.0%

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
n.e.c. is an abbreviation for 'not otherwise classified'

8.5 – Industry sectors entered

This section discusses the extent to which engineering graduates went to work in the engineering sector rather than any other industry. The analysis is based on graduates' responses to the DLHE survey about the business of their employer, which was matched to Standard Industrial Classification (SIC) codes by HESA. These codes identify the primary industrial focus or sector of an employer, and the robustness of this data therefore relies on how accurately graduates understood and described their employer's business.

Engineering and technology graduates

Figure 8.24 shows the proportion of employed engineering graduates working for an organisation identified as within the engineering sector footprint.

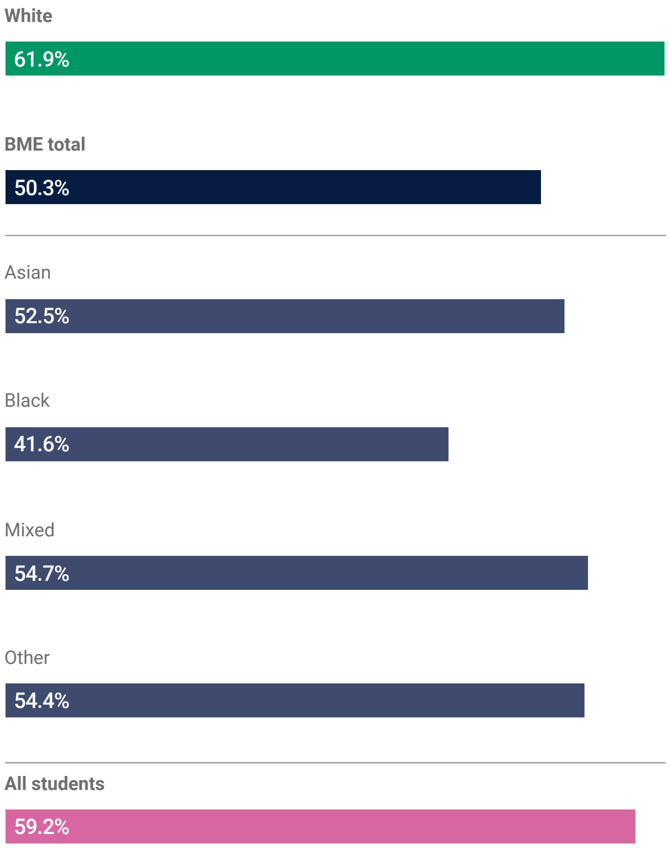
Figure 8.24 Proportion of employed full time UK domiciled engineering and technology leavers working in the engineering sector within 6 months of graduating in 2015 to 16, by discipline – UK

	Engineering sector %
Engineering disciplines (H0-H9)	62.0%
(H1) General engineering	*55.1%*
(H2) Civil engineering	*72.2%*
(H3) Mechanical engineering	*64.1%*
(H4) Aerospace engineering	*60.6%*
(H5) Naval architecture	*57.1%*
(H6) Electronic and electrical engineering	*56.0%*
(H7) Production and manufacturing engineering	*56.2%*
(H8) Chemical, process and energy engineering	*56.9%*
(H9) Others in engineering	*65.5%*
Technology disciplines (J1-J9)	35.3%
(J1) Minerals technology	*64.0%*
(J2) Metallurgy	*59.5%*
(J4) Polymers and textiles	*15.7%*
(J5) Materials technology not otherwise specified	*49.6%*
(J6) Maritime technology	*59.0%*
(J7) Biotechnology	*48.1%*
(J9) Others in technology	*24.5%*
All engineering and technology (H0-J9)	**59.2%**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
Proportions for (H0) Broadly-based programmes within engineering and technology and (J3) Ceramics and glass have been suppressed due to small numbers.

Among UK domiciled students who had studied engineering and technology full time and had found employment within 6 months after graduating, 59.2% were working in the engineering sector. It is evident this proportion varied by engineering discipline, with 72.2% of civil engineering graduates employed in engineering industries compared to just 15.7% of those who had studied polymers and textiles. Employment rates within the engineering sector were also comparatively high for those who had studied mechanical engineering (64.1%), minerals technology (64.0%) and others in engineering (65.5%).

Figure 8.25 Proportion of employed full time UK domiciled engineering and technology leavers working in the engineering sector within 6 months of graduating in 2015 to 16, by ethnicity – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16

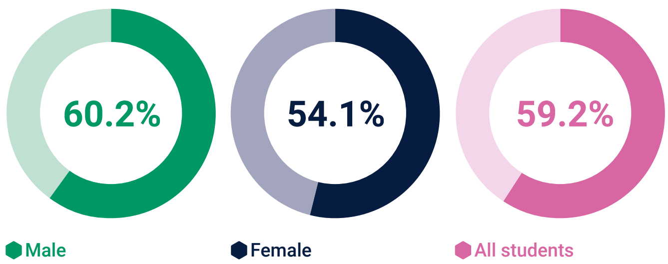
Variations by gender and ethnicity

As discussed previously, women and BME engineering and technology graduates were less likely than their male and white counterparts to enter engineering occupations 6 months after graduation. As **Figures 8.25** and **8.26** illustrate, it is also evident that they are less likely to work in the engineering sector.

Of those who were employed 6 months after graduating, 61.9% of white engineering and technology graduates were working in the engineering sector, compared with 50.3% of their BME peers (an 11.6 percentage point difference) (**Figure 8.25**). This gap was particularly wide between white and black engineering and technology graduates, at 20.3 percentage points.

As **Figure 8.26** shows, there were also gender differences in respect of employment within the engineering sector. Of those who were employed 6 months after graduating, three in five male engineering and technology graduates were working in the engineering sector, compared with 54.1% of their female peers (a 6.1 percentage point difference).

Figure 8.26 Proportion of employed full time UK domiciled engineering and technology leavers working in the engineering sector within 6 months of graduating in 2015 to 16, by gender – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this chart by disability status, see **Figure 8.26a** in our Excel resource.

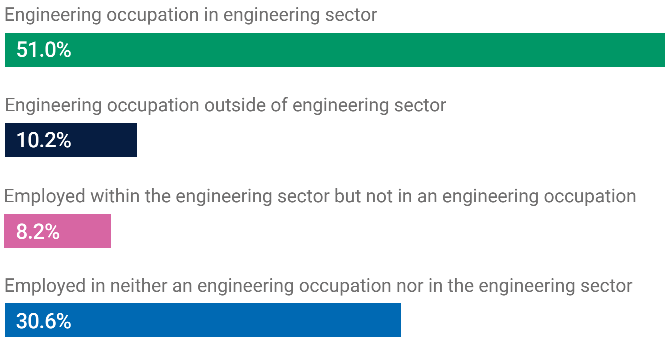
8.6 – Employment within the engineering footprint

The specific occupational role of an employee can be quite different from the primary activity of their employer. It is possible for a graduate to be working in an engineering role for an organisation that is not in the engineering sector, or for them to work in a non engineering role that is in the engineering sector.

Focusing on engineering and technology graduates, this section shows the proportions who were employed:

- in an engineering occupation within the engineering sector
- in an engineering occupation outside of the engineering sector
- within the engineering sector but not in an engineering occupation
- in neither an engineering occupation nor in the engineering sector

Figure 8.27 Full time UK domiciled engineering and technology leavers who found employment within 6 months of graduating in 2015 to 16, by occupation and industry – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16

Figure 8.28 Full time UK domiciled engineering and technology leavers who found employment within 6 months of graduating in 2015 to 16, by occupation, sector and discipline – UK

	Engineering occupation		Non engineering occupation		
	Engineering sector	Non engineering sector	Engineering sector	Non engineering sector	Total no.
Engineering disciplines (H0-H9)	54.7%	10.4%	7.3%	27.6%	9,855
(H0) Broadly-based programmes within engineering and technology	–	–	–	–	5
(H1) General engineering	46.8%	11.4%	8.3%	33.5%	810
(H2) Civil engineering	67.8%	8.1%	4.4%	19.8%	1,865
(H3) Mechanical engineering	58.0%	10.8%	6.1%	25.1%	2,895
(H4) Aerospace engineering	48.5%	10.0%	12.2%	29.3%	1,010
(H5) Naval architecture	52.8%	11.1%	5.6%	30.6%	35
(H6) Electronic and electrical engineering	50.1%	12.7%	6.0%	31.3%	1,830
(H7) Production and manufacturing engineering	47.5%	11.9%	8.7%	32.0%	415
(H8) Chemical, process and energy engineering	44.3%	8.4%	12.4%	34.9%	940
(H9) Others in engineering	57.1%	12.5%	7.1%	23.2%	55
Technology disciplines (J1-J9)	19.2%	8.0%	16.1%	56.7%	1,145
(J1) Minerals technology	55.8%	17.3%	7.7%	19.2%	50
(J2) Metallurgy	46.3%	9.8%	12.2%	31.7%	40
(J3) Ceramics and glass	–	–	–	–	15
(J4) Polymers and textiles	10.0%	20.0%	6.7%	63.3%	90
(J5) Materials technology not otherwise specified	40.6%	9.1%	9.8%	40.6%	145
(J6) Maritime technology	26.2%	5.7%	32.8%	35.2%	120
(J7) Biotechnology	12.5%	2.5%	35.0%	50.0%	80
(J9) Others in technology	10.1%	6.1%	14.3%	69.4%	600
All engineering and technology (H0-J9)	**51.0%**	**10.2%**	**8.2%**	**30.6%**	**11,000**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
'–' represents a percentage that was calculated on a small population (of between 0 and 22.5 inclusive) and therefore suppressed to prevent any misleading interpretation.
To view this table core by related engineering occupations, see **Figure 8.28a** in our Excel resource.

51.0% of full time UK domiciled engineering and technology graduates employed six months of graduating were in an engineering occupation within the engineering sector.

As **Figure 8.27** shows, just over half (51.0%) of full time UK domiciled engineering and technology graduates employed 6 months of graduating were in an engineering occupation within the engineering sector. A further 10.2% were employed in an engineering occupation outside of the sector. Around two in five employed engineering and technology graduates were not working in an engineering occupation, though 8.2% were nevertheless in the engineering sector.

Among the engineering and technology disciplines, civil engineering had the highest rate of graduates working within an engineering occupation in the sector (67.8%) (**Figure 8.28**). This proportion was also relatively high for those who had studied mechanical engineering (58.0%). In contrast, under one in five graduates from technology disciplines were working within an engineering occupation in the engineering sector (19.2%).

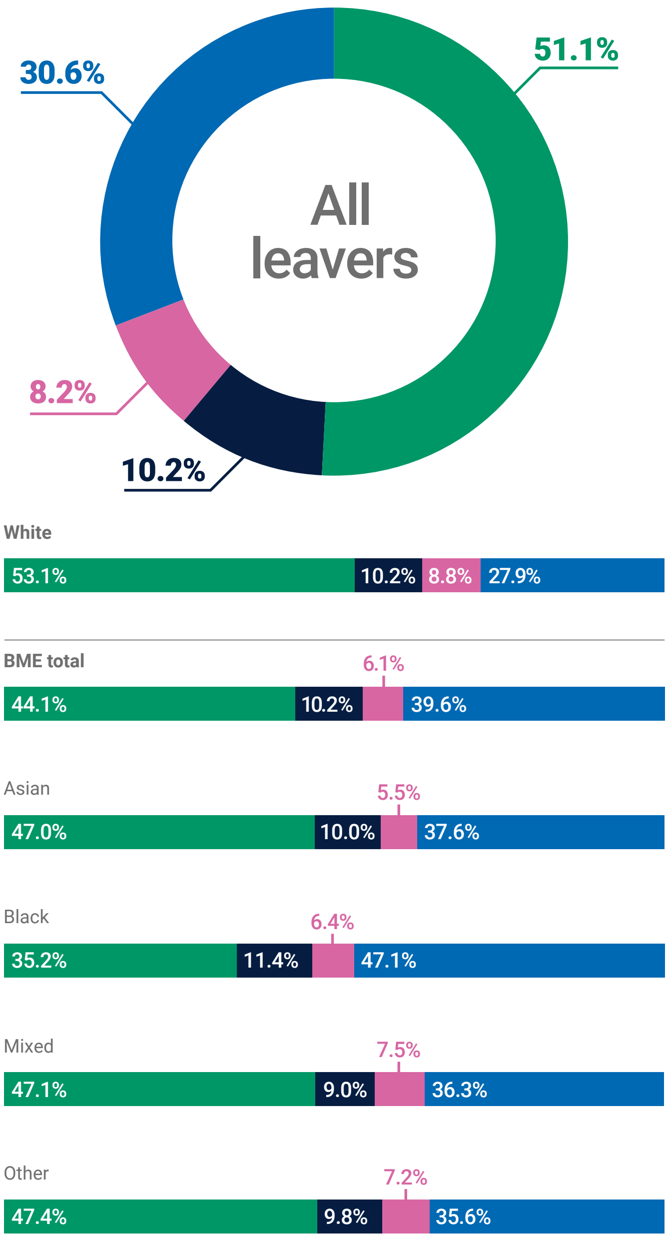
Variations by gender and ethnicity

Women and BME engineering and technology graduates were less likely than their male and white counterparts to enter either engineering occupations or related industries 6 months after graduation.

Among full time UK domiciled engineering and technology graduates, 53.1% white leavers were working in an engineering occupation within the engineering sector 6 months after graduation, compared with 44.1% of BME leavers (**Figure 8.29**). This proportion was particularly low among black graduates, with just 35.2% in an engineering occupation within the sector. In fact, of those who found employment 6 months after graduating, nearly half of black engineering and technology graduates were working in a non engineering-related occupation outside of the sector (47.1%).

53.1% white leavers were working in an engineering occupation within the engineering sector six months after graduation, compared with 44.1% of BME leavers.

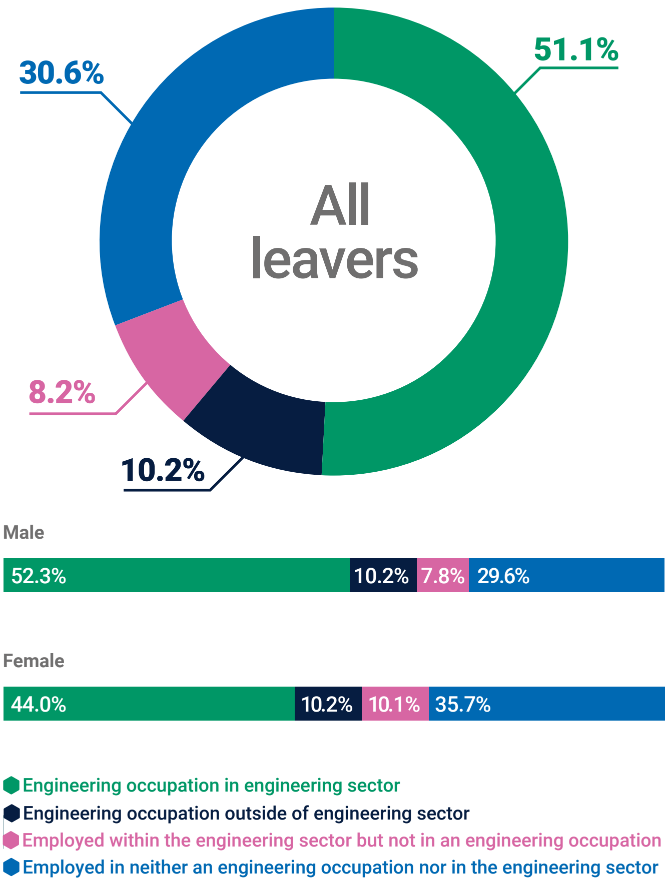
Figure 8.29 Full time UK domiciled engineering and technology leavers who found employment within 6 months of graduating in 2015 to 16, by occupation, sector and ethnicity – UK



- Engineering occupation in engineering sector
- Engineering occupation outside of engineering sector
- Employed within the engineering sector but not in an engineering occupation
- Employed in neither an engineering occupation nor in the engineering sector

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this chart with numbers, see **Figure 8.29** in our Excel resource.

Figure 8.30 Full time UK domiciled engineering and technology leavers who found employment within 6 months of graduating in 2015 to 16, by occupation, sector and gender – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this chart with numbers, see **Figure 8.30** in our Excel resource.

A similar trend was evident among male and female engineering and technology graduates. **Figure 8.30** shows that among UK domiciled engineering and technology students who found employment 6 months after graduating, 52.3% of men were working in an engineering role within the sector, 8.3 percentage points higher than for women (44.0%). Women were more likely to either be working in the engineering sector – but not in an engineering occupation – or working outside of the sector in a non related engineering role entirely.

These results suggest that graduates who are white or male are more likely to secure engineering jobs in the sector, and BME graduates and women are less likely. These differences are a recognised issue in the engineering profession, and in April 2017, the Royal Academy of Engineering entered into the second phase of a programme to increase diversity and inclusion to reflect the UK's increasingly diverse society. It will run until 2020, working to understand and address the extent to which engineering and organisations within it are inclusive and nurture diversity of all kinds.[8.21] Such programmes are encouraging and it will be interesting to see how resulting actions and initiatives will advance equality and diversity in the industry.

Case study –Cummins' approach to gender balanced recruitment

Stuart Proctor, Recruitment Manager, Cummins

In 2015, we challenged our regional technical groups with increasing the gender diversity of our engineering workforce. Our aim was to exceed the UK engineering average of 8 to 10% females by finding new ways of delivering gender balanced recruitment, based on merit.

We decided to focus on our student and graduate opportunities – an area where we hoped we could make a big difference quickly. Our approach was two-pronged. We examined our recruitment processes to understand unconscious biases that may be impacting our hiring decisions. And we focused our attention on increasing the number of suitably qualified women applying to the business, since this was consistently low.

We quickly concluded that we needed to shift our focus, from looking for candidates who could fill business openings immediately, to identifying high calibre individuals who we could develop to meet the future needs of the business. Making this distinction allowed us to be more inclusive in our approach to candidate sourcing.

For example, we looked at the gender split and volume of students graduating from both the 'traditional' engineering degree subjects (mechanical, electrical, automotive, etc.) and 'associated' STEM degree subjects such as maths, physics and chemistry. It became clear that including associated STEM degree subjects within our candidate searches increased the potential female representation by over 40,000 per year or 800%.

Altering our advertising strategy allowed us to attract a broader candidate pool, whilst the selection process has delivered a 50:50 gender mix on graduate offers. We continue to hire the best candidates on merit and our gender balance for overall college hires for 2016 to 2017 stands at 37% - up from 11% in 2014.

8.21 RaEng. 'Diversity and inclusion in engineering'.

8.7 – The UK graduate recruitment market

Context

Despite the uncertainty caused by the EU referendum in 2016, evidence suggests that the UK graduate recruitment market in 2017 is just that – a graduates' market. Analysis conducted by High Fliers Research in December 2016 reveals that employers were stepping up their graduate vacancies by 4.3% in 2017, with extra jobs available in the public sector, at high street and online retailers, and at the major engineering and industrial companies.[8.22] Just 8 employers out of 100 surveyed indicated that they would reduce their graduate recruitment in 2017. These are promising trends for graduates at a time of heightened political unpredictability.

The same analysis showed that the paid work experience programmes also increased, particularly for first year undergraduates, as did paid vacation internships for penultimate year students. It also highlights that the Apprenticeship Levy introduced in April 2017 has not had a negative effect on the graduate market: fewer than 10% of employers cut back on their graduate recruitment in favour of school-leaver recruitment ahead of its introduction.

Graduate starting salaries

This section presents mean salaries reported by graduates 6 months after graduation, by level of study, subject area, engineering and technology sub-disciplines, occupation, industry, and gender and ethnicity. The analysis was restricted to UK domiciled graduates who were in full time employment after graduating from full time study. For ease, mean salaries are referred to as starting salaries.

At £25,607, the mean starting salary of engineering and technology graduates was 18% higher than the average for graduates overall.

First degree undergraduates

Figure 8.31 shows that among UK domiciled first degree graduates who had studied full time, the average starting salary of those entering the labour market in full time jobs was just over £21,700. In comparison, engineering and technology graduates earned £25,607, or 18.0% more (**Figure 8.31**). In fact, the mean salary of engineering and technology graduates 6 months after leaving university was among the highest of all subject areas, only exceeded by medicine and dentistry and veterinary science. First degree graduates in computer science and mathematical sciences also earned relatively high starting salaries, compared with the across-subject average. Of all STEM subjects, graduates in biological sciences and agriculture and related subjects earned the least – both well below the all-subject average.

Figure 8.31 Mean starting salaries of full time UK domiciled first degree leavers who found employment within 6 months after graduating in 2015 to 2016, by subject area – UK

Subject area	Mean salary
STEM subjects	
Agriculture and related subjects	£19,866
Architecture, building and planning	£22,577
Biological sciences	£18,745
Computer science	£24,235
Engineering and technology	£25,607
Mathematical sciences	£24,362
Medicine and dentistry	£29,658
Physical sciences	£21,483
Subjects allied to medicine	£22,189
Veterinary science	£27,583
Total STEM	**£22,858**
Non STEM subjects	
Business and administration studies	£21,880
Combined	£21,072
Creative art and design	£18,054
Education	£20,361
Historical and philosophical studies	£20,107
Languages	£19,476
Law	£19,848
Mass communications and documentation	£18,653
Social studies	£22,500
Total non STEM	**£20,577**
All subjects	**£21,719**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this table with mean starting salaries by gender, level of study and subject area, see **Figure 8.31** in our Excel resource.

8.22 Highfliers Research. 'The graduate recruitment market in 2017. Annual review of graduate vacancies and starting salaries at Britain's leading employers', December 2016.

When analysed by engineering discipline, full time UK domiciled graduates in minerals technology (£29,036) and chemical, process and energy engineering (£27,839) had the highest starting salaries out of all engineering and technology leavers in an engineering occupation within the sector 6 months after graduating. Those who graduated in naval architecture (£24,818) and others in technology (£24,137) had the lowest starting salaries (**Figure 8.32**). These nevertheless were higher than the average starting salary of UK first degree graduates entering the labour market in full time jobs (£21,719).

Among engineering and technology graduates, mean starting salaries were highest for those who had studied minerals technology or chemical, process and energy engineering.

Figure 8.32 Mean starting salaries of full time UK domiciled engineering and technology first degree leavers who found employment within 6 months of graduating in 2015 to 16, by discipline, occupation and sector – UK

	Within engineering sector		Outside of engineering sector		
	Engineering occupation	Non engineering occupation	Engineering occupation	Non engineering occupation	Mean salary total
Engineering and technology (H0-J9)	£26,540	£25,900	£25,566	£22,037	£25,607
(H0) Broadly-based programmes within engineering and technology	–	–	–	–	–
(H1) General engineering	£27,464	£25,538	£26,817	£26,255	£27,121
(H2) Civil engineering	£25,880	£23,219	£26,171	£21,770	£25,445
(H3) Mechanical engineering	£26,567	£31,186	£25,752	£21,385	£26,101
(H4) Aerospace engineering	£26,674	£23,851	£26,478	£20,394	£25,169
(H5) Naval architecture	£24,818	–	–	–	£24,267
(H6) Electronic and electrical engineering	£26,953	£22,031	£25,700	£22,498	£25,699
(H7) Production and manufacturing engineering	£25,402	£25,107	£22,896	£21,668	£24,265
(H8) Chemical, process and energy engineering	£27,839	£26,456	£25,981	£25,436	£26,971
(H9) Others in engineering	–	–	–	–	£22,222
(J1) Minerals technology	£29,036	–	–	–	£28,489
(J2) Metallurgy	–	–	–	–	–
(J3) Ceramics and glass	–	–	–	–	–
(J4) Polymers and textiles	–	–	–	£18,315	£18,610
(J5) Materials technology not otherwise specified	£26,294	£22,802	£19,750	£20,254	£23,874
(J6) Maritime technology	£26,851	–	–	–	£27,039
(J7) Biotechnology	–	–	–	£17,594	£18,210
(J9) Others in technology	£24,137	£22,227	£21,665	£20,058	£21,260

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
Please note that averages for a group of 7 or fewer people are not shown. These suppressions are indicated by '–'
To view this table with core/related engineering salary information, see **Figure 8.32** in our Excel resource.

Overall, engineering and technology first degree graduates earned on average more in engineering roles both within the engineering sector (£26,540) and outside the engineering sector (£25,566) than those who were not in engineering occupations (when comparing occupations within sectors). Both within and outside of the engineering sector, first degree graduates in general engineering working in engineering occupations were the highest earners out of all engineering and technology graduates. Their salaries were only surpassed by graduates in chemical, process and energy engineering and minerals technology, who earned more in engineering occupations within the engineering sector. Similarly, mean salaries for engineering occupations in the sector tended to be higher than for those outside the sector. This is notable, given that BME and female engineering and technology graduates are both more likely to be working in a non-engineering role and outside of the engineering sector than their white and male peers. This may in part drive the ethnic and gender pay gaps observed, which are discussed later in this section.

Figure 8.33 Mean starting salaries of full time UK domiciled taught postgraduate leavers who found employment within 6 months after graduating in 2015 to 2016, by subject area – UK

Subject area	Mean salary
STEM subjects	
Agriculture and related subjects	£21,893
Architecture, building and planning	£26,467
Biological sciences	£23,470
Computer science	£30,256
Engineering and technology	£27,623
Mathematical sciences	£27,788
Medicine and dentistry	£31,784
Physical sciences	£23,642
Subjects allied to medicine	£25,151
Veterinary science	£38,380
Total STEM	**£25,880**
Non STEM subjects	
Business and administration studies	£32,578
Combined	–
Creative art and design	£23,152
Education	£23,345
Historical and philosophical studies	£22,621
Languages	£21,358
Law	£22,898
Mass communications and documentation	£21,589
Social studies	£27,681
Total non STEM	**£24,666**
All subjects	**£25,002**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
Please note that averages for a group of 7 or fewer people are not shown.
These suppressions are indicated by '–'
To view this table with salary information by gender and engineering and technology discipline, see **Figure 8.33** in our Excel resource.

Case study – What are you made of? campaign

Linda Williams, HR Director, Dŵr Cymru Welsh Water

Our 2017 graduate and apprentice recruitment campaign focused on finding the most talented people for each role, whilst emphasising the diverse nature of work in the water industry.

When we launched our recruitment programme in 2011, it was designed to address a number of challenges for Welsh Water:

- Futureproofing our business – bringing fresh ideas and new talent into Welsh Water
- Addressing our ageing workforce – with clear succession plans for our key operational roles
- Enhancing our capability to use new technology
- Creating a learning culture, with increased mentoring and coaching
- Enhancing Welsh Water's brand image, making it an employer of choice
- Creating an inclusive workplace

The campaign also looked at trying to get more women to apply for operational roles: an area where women have traditionally been under-represented in the water industry. Our message is that there is no job here that women cannot do - and raising awareness of this is a key priority for us.

Publicity for our recent graduate intake featured positive, strong male and female role models, across a number of areas of the business. We promoted this message across the traditional press and social media, as well as by visiting higher and further education institutions.

As a result, we not only saw an increase in total applications (up 70% since 2014), but we have built on the progress we've made since 2011 – when we had no female apprentices – to achieve today's total of 10 women in apprentice roles.

Taught postgraduate leavers

Mean salaries for employed engineering and technology graduates were 10.5% higher than the overall average for UK domiciled taught postgraduates who had studied full time, at £27,623 compared with £25,002 (see **Figure 8.33**).

Figure 8.34 Mean starting salaries of full time UK domiciled engineering and technology taught postgraduate leavers who found employment within 6 months of graduating in 2015 to 2016, by discipline, occupation and sector – UK

	Within engineering sector		Outside of engineering sector		
	Engineering occupation	Non engineering occupation	Engineering occupation	Non engineering occupation	Mean salary total
Engineering and technology (H0-J9)	£27,909	£29,296	£27,162	£25,796	£27,623
(H0) Broadly-based programmes within engineering and technology	–	–	–	–	–
(H1) General engineering	£26,906	£26,087	–	£33,748	£28,088
(H2) Civil engineering	£26,088	£25,950	£27,841	£25,632	£26,184
(H3) Mechanical engineering	£28,831	£29,375	£28,027	£23,488	£28,294
(H4) Aerospace engineering	£30,411	£55,625	–	–	£33,518
(H5) Naval architecture	–	–	–	–	–
(H6) Electronic and electrical engineering	£31,434	£33,097	£29,644	£30,101	£31,051
(H7) Production and manufacturing engineering	£29,510	–	–	£25,910	£26,933
(H8) Chemical, process and energy engineering	£27,314	£26,722	–	£25,973	£26,618
(H9) Others in engineering	£27,898	–	–	–	£28,299
(J1) Minerals technology	£26,440	–	–	–	£25,129
(J2) Metallurgy	–	–	–	–	–
(J3) Ceramics and glass	–	–	–	–	–
(J4) Polymers and textiles	–	–	–	–	–
(J5) Materials technology not otherwise specified	–	–	–	–	–
(J6) Maritime technology	–	–	–	–	–
(J7) Biotechnology	–	£21,935	–	£23,143	£22,157
(J9) Others in technology	–	–	–	£24,606	£26,432

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
Please note that averages for a group of 7 or fewer people are not shown. These suppressions are indicated by "–"
To view this table with core/related engineering salary information, see **Figure 8.34** in our Excel resource.

The highest earners among engineering and technology taught postgraduates were for aerospace engineering (£33,518) and electronic and electrical engineering (£31,051) (see **Figure 8.34**). Taught postgraduates from technology disciplines earned on average less than those from engineering disciplines. It should be noted, however, that due to small numbers in technology disciplines, the majority of starting salaries have been suppressed.

Unlike first degree graduates, engineering and technology taught postgraduates working within the engineering sector earned more on average when they worked in non-engineering occupations. However, some disciplines show the reverse. In fact, a large differential in aerospace engineering mean salaries - £55,625 for non-engineering occupations against £30, 411 for engineering occupations – is partly responsible for this headline figure. Those working outside the engineering sector earned more overall in engineering occupations.

Figure 8.35 Mean starting salaries of full time UK domiciled research postgraduate leavers who found employment within 6 months after graduating in 2015 to 2016, by subject area – UK

Subject area	Mean salary
STEM subjects	
Agriculture and related subjects	£29,202
Architecture, building and planning	£31,621
Biological sciences	£32,177
Computer science	£38,172
Engineering and technology	£34,128
Mathematical sciences	£34,435
Medicine and dentistry	£37,607
Physical sciences	£31,019
Subjects allied to medicine	£33,393
Veterinary science	£36,028
Total STEM	**£33,454**
Non STEM subjects	
Business and administration studies	£40,057
Combined	..
Creative art and design	£27,586
Education	£34,320
Historical and philosophical studies	£28,277
Languages	£28,908
Law	£42,349
Mass communications and documentation	£29,506
Social studies	£33,542
Total non STEM	**£31,704**
All subjects	**£33,092**

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
Please note that averages for a group of 7 or fewer people are not shown.
These suppressions are indicated by '–'
To view this table with salary information by gender and engineering and technology discipline, see **Figure 8.35** in our Excel resource.

At £34,128, the mean starting salary of engineering and technology research postgraduates is 3.1% higher than for all graduates at this level.

Case study – Hopes and experience of an engineering graduate

Bethany Selwyn, graduate civil engineer, Transport for London

As a civil engineering graduate, I am constantly learning new things and developing my engineering skills and knowledge. The Transport for London graduate scheme allows me to move around the company, experiencing a variety of roles in different departments. At the end of the scheme, I hope to have had experience in a mixture of small and large projects - out on site, design work, operational roles and more. All of these roles will give me the experience required to become a well-rounded engineer with enough skills and competence to gain chartership with the Institute of Civil Engineers.

The best part of the graduate scheme is learning about yourself as an engineer and understanding what role will suit you best. Currently, I am not sure where will be best for me at the end of this scheme. My first two placements have been working on small projects with a lot of responsibility. My next placement will allow me to work on a bigger project to see what suits me better as an engineer.

Civil engineering is rewarding as it allows me to make an impact on people's lives. Whether it is a small project like reinstating a bridge which was damaged by a fire or a large project like the Northern Line Extension, each benefits the surrounding environment and people. You get the chance to use skills like problem solving and every day is different and presents a new challenge.

Research postgraduate leavers

As we have previously stated, research postgraduates command higher salaries than other levels in engineering and technology. At £34,128, they earned 3.1% more than the all-subject average of £33,092 (see **Figure 8.35**).

With a mean salary of £44,264, research postgraduates in chemical, process, and energy engineering working in engineering occupations within the sector were the highest earners of all the engineering disciplines (**Figure 8.36**). However, the lowest earners – mechanical engineering graduates in engineering occupations outside of the sector – fell significantly below the average, with a starting salary of £22,773.

Mean starting salaries were higher in the engineering sector than outside it, at around £36,000 compared with £32,000. However, the differences between engineering and non engineering occupations were minimal.

Figure 8.36 Mean starting salaries of full time UK domiciled engineering and technology research postgraduate leavers who found employment within 6 months of graduating in 2015 to 2016, by discipline, occupation and sector – UK

	Within engineering sector		Outside of engineering sector		
	Engineering occupation	Non engineering occupation	Engineering occupation	Non engineering occupation	Mean salary total
Engineering and technology (H0-J9)	£36,529	£36,036	£32,168	£32,468	£34,128
(H0) Broadly-based programmes within engineering and technology	–	–	–	–	–
(H1) General engineering	£36,915	£37,098	£36,566	£32,558	£35,261
(H2) Civil engineering	£32,173	–	£34,207	£36,384	£34,691
(H3) Mechanical engineering	£33,665	–	£22,773	£32,616	£31,542
(H4) Aerospace engineering	–	–	–	–	£33,688
(H5) Naval architecture	–	–	–	–	–
(H6) Electronic and electrical engineering	£37,091	–	£32,178	£30,994	£34,485
(H7) Production and manufacturing engineering	–	–	–	–	–
(H8) Chemical, process and energy engineering	£44,264	£34,510	£33,369	£31,489	£35,567
(H9) Others in engineering	–	–	–	–	–
(J1) Minerals technology	–	–	–	–	–
(J2) Metallurgy	£37,992	–	–	–	£33,555
(J3) Ceramics and glass	–	–	–	–	–
(J4) Polymers and textiles	–	–	–	–	–
(J5) Materials technology not otherwise specified	–	–	–	£31,748	£33,953
(J6) Maritime technology	–	–	–	–	–
(J7) Biotechnology	–	–	–	–	–
(J9) Others in technology	–	–	–	–	–

Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
Please note that averages for a group of 7 or fewer people are not shown. These suppressions are indicated by '–'
To view this table with core/related engineering salary information, see **Figure 8.36** in our Excel resource.

Case study – Producing employment ready graduates at Heriot-Watt University

Keith Kilgore, Careers Advisor, Heriot-Watt University

A key element of the learning and teaching strategy for Heriot-Watt University is to embed a distinctive set of graduate attributes in all of our taught programmes, along with delivering a research-informed, professionally relevant, international and multidisciplinary curriculum. In this way, we aim to support the employability of our students and foster a spirit of entrepreneurship.

Several initiatives in the engineering subject area illustrate this approach. Engineering students are required to complete projects as part of the compulsory subjects of engineering/process design and engineering manufacturing, and these are provided and supported by partner companies. By working alongside students, these businesses help them develop an understanding of the real working challenges of industry.

In addition, we offer two specific courses that focus on developing employability skills in the curriculum:

Business awareness, safety and sustainability: This involves weekly employer engagement with over 200 2nd and 3rd year undergraduates across chemical, mechanical and electrical/electronic engineering courses. Guest lectures from company partners give industry insight and contextualisation to aspects covered during the rest of this core project-based course.

The aim is to put a practical engineering perspective on the theoretical elements of the course, focussing on the commercial as well as technical elements of students' industry related projects and helping students to realise some of the important softer skills that recruiters are looking for.

Professional and industrial studies: This course is delivered in the final MEng year, with final year students supervising project teams from the earlier course, as well as completing their own projects. This further enhances their understanding of applied engineering project management. The courses are designed to fulfil the requirements of UK-SPEC guidelines.

Keith Kilgore, careers adviser for engineering programmes says, "In addition to key technical understanding, the programmes at Heriot-Watt work to develop those 'soft' skills of communication and teamwork, for example. They give our students a skillset which helps to make them effective in the workplace and our collaboration with industry colleagues is instrumental in this."

Variations by gender and ethnicity

Across all levels of study, female engineering and technology graduates consistently earned less than their male peers. The gender pay gap was widest among research postgraduates (8.4%) and smallest among first degree graduates (1.7%) (**Figure 8.37**).

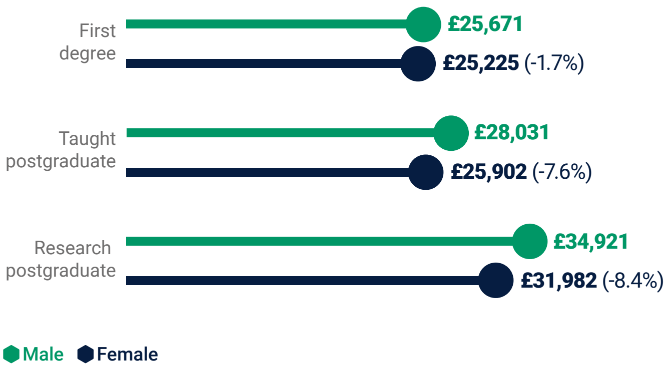
Examination of the gender pay gap by discipline and level of study presents a more complex picture (for brevity, this data has not been presented here, but can be found in our Excel resource). For example, first degree female graduates achieved higher starting salaries than male graduates in production and manufacturing engineering, and electronic and electrical engineering. Similarly, female taught postgraduates in mechanical engineering earned more than men. Conversely, first degree female graduates had lower starting salaries than male graduates in mechanical engineering and general engineering, as well as materials technology not otherwise specified. Women also earned on average less than men in all engineering and technology disciplines among research postgraduates, as well as among taught postgraduates with the exception of mechanical engineering, where women earned slightly more than men (a difference of 2.2%).

It must be pointed out that this analysis takes no account of the occupations that graduates entered, so there is no immediate suggestion here of a gender pay gap for comparable jobs. However, the particularly wide gap in postgraduate research is concerning.

Variances in starting salaries were smaller between white and BME engineering and technology graduates, and not altogether consistent. For example, while BME first degree graduates earned 2.2% less than their white counterparts, at taught and research postgraduate levels their average earnings were higher (see **Figure 8.38**).

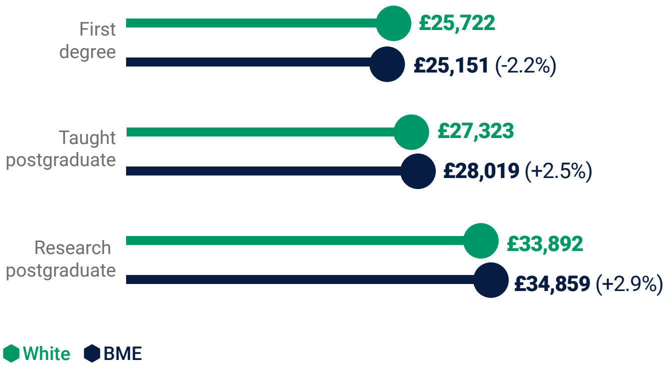
Likewise, as the more detailed tables in our Excel resource show, the ethnic pay gap varied widely by discipline, level of study, and ethnic group. First degree graduates of mixed origin, for example, had a 1.3% higher starting salary than white graduates, while for black first degree graduates it was 4.0% lower. Among taught postgraduates, the situation was reversed, with black graduates having the highest starting mean salary out of all ethnic groups.

Figure 8.37 Mean starting salaries of UK domiciled engineering and technology leavers in full time employment 6 months after graduating in 2015 to 2016, by level of study and gender – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16

Figure 8.38 Mean starting salaries of UK domiciled engineering and technology leavers in full time employment 6 months after graduating in 2015 to 2016, by level of study and broad ethnic group – UK



Source: HESA, Destinations of Leavers from Higher Education Survey 2015/16
To view this chart by more detailed ethnic group, see **Figure 8.38** in our Excel resource.

Case study – UK reliance on EU immigration

Philip Campbell, Policy Team Leader, Recruitment & Employment Confederation

In 2017, the Recruitment & Employment Confederation (REC) commissioned the Migration Policy Institute to analyse the EU contribution to the UK workforce, using the ONS annual population survey and labour force survey. EU nationals were more likely than UK nationals to be working and made up around 7% (2.2 million) of the UK workforce. However, even though the UK relies on their labour, nearly 1.7 million of these would not qualify for permanent residence under current rules.

Relative to their share of the total UK workforce, EU nationals were over-represented in a number of sectors in 2016, including manufacturing at 10.6% or 319,300 workers and construction at 8.4% or 192,400 workers. Other sectors also employed large numbers of EU nationals. For example in 2016, 87,100 information and communication workers, and 157,200 professional, scientific and technical workers were EU nationals: 6.9% in each sector.

London has heavily relied on EU nationals: they make up 16.7% of London's total workforce and a third of its construction workforce. To a lesser extent, this has been true elsewhere. For instance, 18,700 manufacturing workers in Northern Ireland were EU nationals. In Yorkshire and the Humber, 30,800 manufacturing workers were EU nationals, as were 43,500 in the East Midlands and 38,100 in the West Midlands.

Once outside of the European Union, the UK will need an immigration system that is responsive to employer needs, protects UK workers and supports their communities.

Engineering: why higher education must deliver employability not employment

While more young people than ever are entering higher education, the skills gap – in engineering, in particular – remains canyon-wide.

Engineering graduates have a better chance of getting a professional job and, when they do, they earn more than other graduates. The analysis in this chapter shows as much. As a community, then, we should ensure schools, teachers, careers advisors, parents and, most of all, young people are aware of this.

Engineering's promise of a rewarding career is not new but, to date, it hasn't been enough to entice an adequate supply of young people to study the discipline. Nor does the Destination of Leavers from Higher Education (DLHE) survey tell us what we need to know about why engineering graduates are so attractive to employers.

While more young people than ever are entering higher education, the skills gap – in engineering, in particular – remains canyon-wide. Brexit is likely only to widen it further. Meanwhile, although employment rates are good, employers consistently complain that graduates are not 'work ready.' Given this situation, it's no surprise that the word 'employability' is being chanted in academia like a mantra. If graduates had greater employability, it is claimed, they'd be able to add value from day 1 of their graduate-level career. So, it is argued, universities must be at fault if they are failing to deliver it.

Engineering Professors COUNCIL
The voice of engineering academics

Johnny Rich,
Chief Executive,
Engineering Professors' Council

We must be careful, however. Employability is not the same as employment. Employment is having a job. Employability is the set of attributes required to get a job, to keep it and to get on in it. In a recession, even as employment falls, employability will often rise as people improve their skills and qualification to compete for scarcer jobs.

Jo Johnson, the universities minister, made regular reference to employability as a key output of higher education as he insisted on the need for the Teaching Excellence Framework (TEF) to measure outputs. However, the TEF includes no metric (nor, I would argue, any qualitative assessment) of employability. One of the core metrics in this year's TEF is the Destination of Leavers survey, but this is the *employment* rate, not a measure of *employability*. It depend as least as much on a university's location, on its range of courses and on its student intake as it does on its teaching.

The other metrics in TEF are similarly poor proxies for actual teaching quality. Johnson has missed an opportunity to genuinely promote better teaching and employability rather than creating another higher education league table.

It should be said, however, that any actual evidence of poor teaching is sparse. Record high levels of student satisfaction don't support that claim, nor does the fact that in TEF's first year (2016) not a single higher education institution was deemed to be failing. And this year, with the introduction of the bronze, silver and gold TEF awards, the government was at pains to point out that, although bronze was the lowest category, it too represented a high level of excellence.

5 components of employability

- Knowledge
- Character attributes
- Hard skills
- Social capital
- Soft skills

The challenge for higher education is to support students to develop soft skills and character components of employability, in a more deliberate way.

For 2018, TEF has been renamed the Teaching Excellence and Student Outcomes Framework and will be taken even further away from a realistic measure of the learning that students are helped to achieve. So, given that it doesn't measure employability, how could we do so and, in the process, do something positive to encourage greater and more effective focus on eliminating skills gaps through higher education?

Firstly, we need to understand what makes a graduate – or anyone – employable. There are 5 main components: knowledge; hard skills (job-specific competencies); soft skills (transferable skills, such as communication, teamwork or analytical skills); character attributes (including attitude, behaviours and personality); and social capital.

While it would be unrealistic to dismiss its relevance, social capital (or the value of the individual as perceived by society) is often given more weight in recruitment choices than is desirable. Perhaps if we could better articulate the extent to which graduates possess the other components, then social capital would not be such a force.

Traditionally, higher education has been successful in imparting the first 2 components – knowledge and hard skills – particularly in engineering. It sets out to do so deliberately and it assesses them according to a framework that aligns with subsequent accreditation.

Higher education has been less explicit in developing soft skills and character attributes. Yet these are exactly the ingredients that create that property of 'graduateness' for which employers are unwaveringly willing to pay a significant premium.

We all need to recognise an employable engineer is someone with a diverse set of skills and we need to take that message into schools and communities.

Engineering graduates develop some of these ingredients – such as critical thinking, creativity, enterprise, initiative, analytical skills, work ethic, etc – exceptionally well, which is why they are in high demand even beyond engineering roles. It is because they are so broadly employable that, to plug the skills gap, we need an oversupply of engineering graduates as some will always be lost to the sector.

Although higher education develops these soft skills and character components of employability, the challenge is to do so in a more deliberate way. That means setting out a framework of employability attributes as learning goals, helping students to see what activities will build these skills, and supporting reflection on what they've learned. We should be measuring this kind of 'learning gain' as well as academic outcomes. The UK's higher education funding bodies are embarked on an exploratory project to do just that.

Employers too should understand better their own expectations outside the purely academic, be more explicit in asking for what they want, and do more to help students meet those expectations. It's no use complaining about 'work-readiness' unless you are prepared to define the gaps and help to close them.

University teaching can always improve and become more professionalised, but TEF will do nothing to address the engineering skills gap: it is too focused on poor metrics and ill-conceived notions of what might constitute 'value for money'. Instead, there are 3 areas on which universities and employers can focus:

Firstly, they need to work more closely to understand each other's needs and challenges and to create work-related learning opportunities for students.

Secondly, university engineering departments should create co-curricular opportunities to develop transferable skills and character alongside a demanding programme of studies.

Thirdly, and most importantly, we all need to recognise an employable engineer is someone with a diverse set of skills and we need to take that message into schools and communities. By creating a wider demand, we will be better able to develop that diversity, not only in the skills, but also in the gender, ethnicity and social demography of future engineers.

As for the UK and devolved governments, there is a welcome appetite to review how best to fund higher education. In doing so, we urgently need to recognise that skills gaps will never be filled so long as the higher education courses on offer are dictated solely by the choices of students who have often had poor guidance. Funding is the best policy lever to ensure the wider demands of industry, of the economy and of society are also met.

9 - Employment and salary trends

Nominal salaries are rising amidst high demand for engineering workers – though in real terms, wages are stagnating because of low productivity and inflation

Median salaries for full time employees (2016)
Civil engineers: £40,953
Mechanical engineers: £41,808
Electrical engineers: £44,696
All occupations: £28,195

Key points

Employment trends

The economy has not suffered as much as the treasury predicted it would following the UK's decision to leave the EU, but there are signs that this resilience is declining because of the falling pound and rising prices. There is also evidence to suggest the EU referendum result has had a negative impact on net migration numbers.

Demand for labour, however, has remained robust, and in areas for which there are skills shortages, including engineering, the labour market is being constrained by a lack of supply. The most recent ONS Vacancy Survey suggests vacancy numbers across all industries for the period April to June 2017 were the highest since 2001. Large year-on-year changes in the number of vacancies have been seen in certain industries, including mining and quarrying (up 66.7%), construction (up 27.0%) and public administration and defence (up 23.8%). Similarly, out of 9 job sectors monitored by REC, demand for permanent staff was found to be highest in engineering.

Median salaries

The median salaries of full time employees working in engineering occupations in 2016 (ranging between £32,987 and £47,394)compared very favourably to the overall average of £28,195. For example, the median salary of civil engineers was £40,953, for mechanical engineers it was £41,808, and for electrical engineers it was £44,696. Certain engineering-related professions earned more highly still, including aircraft pilots and flight engineers (£87,570) and information technology and telecommunications directors (£69,995).

There is evidence to suggest that the scarcity of candidates together with rising demand has had a positive knock-on effect on starting salaries. However, although there have been nominal wage rises, real wages in fact appear to be stagnant. Economists have speculated that this wage stagnation is a consequence of both the UK's low labour productivity and the inflation it has experienced since the country's decision to leave the EU.

The gender pay gap

Compared with many other countries, the UK lags significantly behind in respect of gender pay differences. Across all employees working full time, men on average earned more than women, with a £5,719 and £8,896 difference in their median and mean salaries respectively. Though these figures should not be taken as evidence of unequal pay, they nevertheless provide an indication of underlying factors such as gender differences in job levels, caring responsibilities, skill required, mode of employment or discrimination.

A gender pay gap was observed among core engineering occupations for which there was salary data available for male and female full time employees. However, in only 7 'core' engineering occupations was the gender difference in median salary larger than for all employees within their respective SOC major groups – and in only 3 was this the case for mean salaries. This suggests that while there is a gender pay gap in engineering, it is generally smaller than observed more widely in the workforce. Research by Deloitte similarly suggests that the gap in starting salaries between men and women who have studied STEM subjects, and who go on to take jobs in these sectors, is smaller than among other professions.

Nevertheless, it remains that in almost all cases where the gender pay gap among engineering occupations exceeded that found in its SOC major group, there were at SOC 1 and 2. This implies that gender pay differences within the engineering occupations may be a particular issue at higher levels i.e managerial, director, and senior roles (SOC 1) and professional occupations (SOC 2).

Earning variation by sector and region

Of the 2,743 engineers surveyed by *The Engineer*, those in the oil and gas industry commanded the highest salaries, with an average salary of £54,461. This was closely followed by those working in the energy, renewables and nuclear sector (£51,953) and the chemicals, pharmaceuticals and medical sector (£51,750). Out of the 11 sectors examined, academia was found to have the lowest average salary (£43,809) despite respondents within this sector being the oldest on average and highly qualified relative to other industries. Salaries in other engineering sectors were found to be closely clustered around the overall average of £48,197.

Similarly, *The Engineer* found earnings varied widely by region, with the average salary being highest for engineers in London and the South East. This generally corresponds to our analysis of ONS data. There were, however, some exceptions by engineering occupation. For example, civil engineers, electrical engineers and IT engineers earned more on average in the South East, sheet metal workers and electrical and electronics technicians earned more in the East of England and paper and wood machine operatives more in Scotland. It is nevertheless clear that engineering occupations offer strong potential for high earnings right across the UK.

9.1 – Context

The EU referendum

Before the EU referendum, predictions by HM Treasury indicated a decision to leave would adversely affect employment and the UK's economy.[9.1] Subsequent measures have found that the economy has not suffered to the extent predicted by the treasury, at least in the months immediately following the referendum.[9.2] The UK's gross domestic product (GDP) grew strongly in the quarter immediately following the referendum (0.5%) and in the final quarter of 2016 (0.7%).[9.3] However, at the time of writing (July 2017), there have been signs that this resilience is receding, most probably as a consequence of the falling pound and rising prices. Following downward trends within the services sector and household, in May the Office for National Statistics (ONS) revised down its initial estimate of growth in UK GDP in the first quarter of 2017 to 0.2%.[9.4]

As discussed in **Chapter 7**, EU workers are a significant part of the skills supply in a number of engineering-related industries, and particularly manufacturing (where they represented 11.5% of the workforce in the first quarter of 2017).

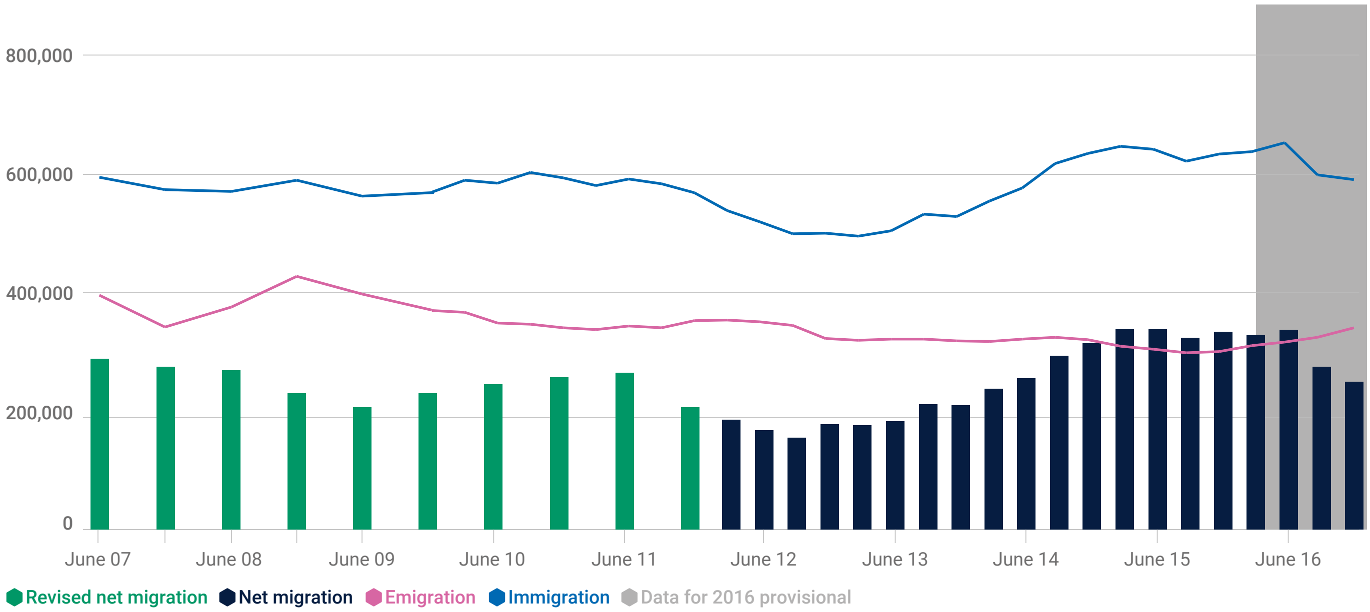
There has been evidence to suggest the UK's vote to leave the EU has had an impact on net migration numbers. Data from the most recent International Passenger Survey undertaken by ONS, which covered the 6 months following the EU referendum, saw a statistically significant decline in net long-term migration numbers from 332,000 in 2015 to 248,000 in 2016 (**Figure 9.1**).[9.5] ONS noted that this fall was partly driven by a fall in immigration and a rise in emigration by EU citizens, with 2016 seeing the smallest net migration estimate for the EU8 countries since they joined the EU in 2004.[9.6]

It is generally accepted that the full impact of the EU referendum will not become clear until negotiations develop and there is more certainty around trade and labour migration arrangements. However, research by the Recruitment and Employment Confederation (REC) suggest that despite a softening of recruitment intentions, demand for labour has remained robust. In areas for which there are skills shortages, including engineering, the labour market is being constrained by a lack of supply.[9.7]

The gender pay gap

Differences in the average earnings between men and women have been apparent in the UK workforce for a long time (**Figure 9.2**). The gap has been closing, but at a slow rate: data from the Annual Survey of Hours and Earnings (ASHE) shows that at 18.1% overall it is the lowest it has been since the survey began in 1997.[9.8] Research by Deloitte estimates that with the pay gap closing at a rate of just 2.5 pence per year, average earnings in the UK will not reach gender parity until 2069 without concerted action.[9.9]

Figure 9.1 Migration data from 2007 to 2016 – UK



Source: ONS, Migration Statistics Quarterly Report: May 2017
To view this chart with numbers, see **Figure 9.1** in our Excel resource.

9.1 HM Treasury and The Rt Hon George Osborne. 'HM Treasury analysis: the immediate economic impact of leaving the EU', May 2016.
9.2 Employment Related Services Association (ERSA). 'Employment Support in the UK: Key statistics briefing', March 2017.
9.3 Independent and Chu B. 'UK economy grows more slowly than expected in first quarter 2017', May 2017.
9.4 Office for National Statistics (ONS). Statistical Bulletin, 'Second estimate of GDP: Jan to Mar 2017', May 2017.
9.5 ONS. Statistical Bulletin, 'Migration Statistics Quarterly Report: May 2017', May 2017.
9.6 EU8/A8 countries: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia.
9.7 Recruitment & Employment Confederation. 'Report on Jobs', July 2017.
9.8 ONS. Statistical bulletin: 'Annual Survey of Hours and Earnings: 2016 provisional results', October 2016.
9.9 Deloitte. 'Deloitte analysis: without action gender pay gap won't close until 2069', September 2016.

Eliminating work-related gender gaps could add £150 billion to our annual GDP in 2025.

The UK lags significantly behind other countries in respect of gender pay differences. According to the Global Talent Competitiveness Index (GTCI) 2017, an annual benchmarking report that measures the ability of countries to compete for talent, the UK is ranked 42nd out of 118 countries for gender earnings (defined by the GTCI as the estimated income earned by women over the corresponding value for men).[9.10]

It is therefore unsurprising that the gender pay gap is a key policy priority, with the issue highlighted in Prime Minister Theresa May's first speech.[9.11] In addition to arguments for equality and fairness, the UK government has suggested that closing the gender pay gap would provide significant economic benefit to the country. According to the Government Equalities Office, eliminating work-related gender gaps could add £150 billion to our annual GDP in 2025.[9.12] And when announcing new regulations on publishing gender pay gap data, minister for women and equalities Justine Greening said, "Helping women to reach their full potential isn't only the right thing to do – it makes good economic sense and is good for British business."[9.13]

These new regulations, which came in force in April 2017 under the Equality Act 2010, require organisations with 250 or more employees to publish:

- their gender pay gap data
- details of the proportion of male and female employees in different pay bands
- their gender bonus gap
- a breakdown of how many women and men get a bonus

Vacancy numbers for the period April to June 2017 were the highest they have been since 2001.

According to the government, these regulations, which will affect almost 8,000 employers with around 11 million employees, aim to "shine a light on workplace practices that could prevent women from reaching senior jobs." [9.14]

In this context, this chapter will consider trends in employment and salary, and where possible will analyse them by gender. However, although the gender pay gap data calculated by ONS (which organisations are also now required to publish) may highlight differences in the average earnings between men and women, it should not be interpreted as an indicator of equal pay. This is because national gender pay gap data is calculated using data from the Annual Survey of Hours and Earnings (ASHE), based on hourly earnings excluding overtime, and does not show differences in the rate of pay for comparable jobs. In the absence of any national framework for job evaluation (as exists, for example, in some Eastern European countries), this approach cannot indicate whether comparable jobs are remunerated similarly across genders. Nevertheless, gender pay gap data calculated in this way provides some indication of underlying factors such as gender differences in job levels, caring responsibilities, skill required, mode of employment (whether part time or full time) or discrimination.[9.15, 9.16]

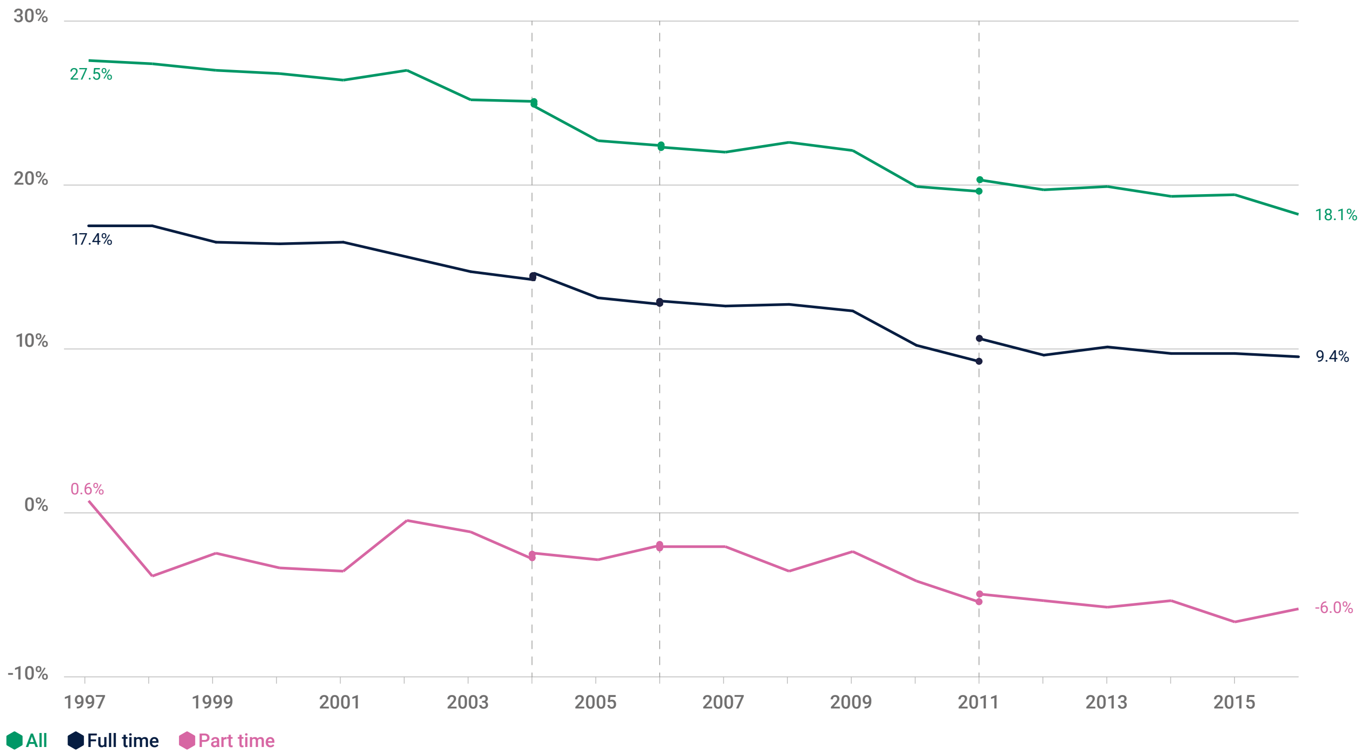
9.2 – Employment demands

Official national statistics suggest UK employment has been robust. From December 2016 to February 2017 and from March to May 2017, the number of people in work increased and the number of people either unemployed or economically inactive fell. Estimates from the Labour Force Survey show that for the period March to May 2017, the employment rate (the proportion of people aged from 16 to 64 who were in work) was 74.9%, the highest since comparable records began in 1971. Unemployment was also low at 4.5%, which was down from 4.9% a year earlier and the lowest since 1975.

Demand for labour has also been strong, with data from the Office for National Statistics' most recent Vacancy Survey suggesting job vacancy numbers for the period April to June 2017 were the highest they have been since 2001 (**Figure 9.3**).[9.17] Overall, there were 2.6 job vacancies for every 100 filled employee jobs in this period, though that ratio varied widely by industry. Notably, job vacancy ratios were even higher in some engineering-related industries, such as information and communication (3.3) and electricity, gas, steam and air conditioning (3.2). In addition, there have been particularly large year-on-year percentage changes in the ratio of vacancies to filled jobs in certain industries, including mining and quarrying (up 66.7%), construction (up 27.0%), and public administration and defence (up 23.8%) (**Figure 9.4**).

9.10 INSEAD, Adecco and HCLI. 'The Global Talent Competitiveness Index 2017 - Talent and Technology', December 2016.
9.11 Publications Office of the European Union. 'Tackling the gender pay gap in the European Union', 2014.
9.12 Government Equalities Office and The Rt Hon Justine Greening MP. 'Gender Pay Gap Reporting Goes Live', April 2017.
9.13 Government Equalities Office and The Rt Hon Justine Greening MP. 'Gender Pay Gap Reporting Goes Live', April 2017
9.14 Government Equalities Office. 'New website reveals Gender Pay Gap by profession', December 2016.
9.15 The Fawcett Society. 'Gender Pay Gap by Ethnicity in Britain', March 2017.
9.16 Equality and Human Rights Commission. 'Step 4: Causes of gender pay differences', August 2016.
9.17 CIPD and Adecco. 'Labour Market Outlook: Views from Employers, Spring 2017', May 2017.

Figure 9.2 Gender pay gap for median gross hourly earnings (excluding overtime) from 1997 to 2016 – UK



Source: ONS, Annual Survey of Hours and Earnings, 1997-2016
Please note that dashed lines represent discontinuities in 2004, 2006 and 2011 ASHE estimates.

Figure 9.3 Number of vacancies seasonally adjusted, in April to June each year from 2001 to 2017 – UK

Source: ONS, Vacancy Survey 2001-2017
To view this chart with numbers, see **Figure 9.3** in our Excel resource.

Figure 9.4 Vacancies by industry from April to June 2017 – UK

SIC industries	No.	Vacancy ratio (vacancies per 100 filled jobs)	Change over 1 year (%)
Accommodation and food service activities	91,000	4.3	13.4% ▲
Administrative and support service activities	53,000	2	7.5% ▲
Arts, entertainment and recreation	19,000	2.5	17.6% ▲
Construction	27,000	2	27.0% ▲
Education	49,000	1.8	1.3% ▲
Electricity, gas, steam and air conditioning supply[1]	4,000	3.2	10.0% ▲
Financial and insurance activities	32,000	3.2	5.6% ▲
Human health and social work activities	120,000	3	2.2% ▲
Information and communication	41,000	3.3	-6.6% ▼
Manufacturing	52,000	2.1	11.9% ▲
Mining and quarrying	1,000	1.9	66.7% ▲
Motor trades	14,000	2.5	-0.7% ▼
Other service activities	19,000	3	-10.9% ▼
Professional scientific and technical activities	65,000	2.6	-0.3% ▼
Public admin and defence; compulsory social security	16,000	1.3	23.8% ▲
Real estate activities[2]	10,000	2.1	1.0% ▲
Retail	98,000	3.3	-0.7% ▼
Total services	686,000	2.7	2.5% ▲
Transport and storage	29,000	2.1	-17.9% ▼
Water supply, sewerage, waste and remediation activities	4,000	1.9	9.1% ▲
Wholesale	30,000	2.6	13.5% ▲
Wholesale and retail trade; repair of motor vehicles and motor cycles	142,000	3	2.1% ▲
All vacancies[2]	**774,000**	**2.6**	**3.9% ▲**

Source: ONS. Vacancies by industry, September 2017
1. Not seasonally adjusted. These series do not display seasonality. Therefore the unadjusted series is the best estimate of a 'seasonally adjusted' series.
2. Excludes Agriculture, forestry and fishing

While demand for staff is rising, the number of available candidates has declined sharply.

Data from a range of recruitment surveys supports the fact that staff are in high demand. A monthly survey of the Recruitment & Employment Confederation (REC), which covers 400 consultancies, found demand for staff hit a 21-month high in May 2017.[9.18] REC's Jobs Vacancy Index uses data from recruitment consultancies to generate a reading of staff demand, with a figure above 50 signalling a higher number of vacancies than the previous month: in May and June 2017, this index sat at 63.3 and 63.0 respectively.

Notably, out of 9 job sectors in which staff demand was monitored by REC, the highest demand for permanent staff in June 2017 was in engineering (68.4, up from 61.4 in the previous year), followed by accounting/financial and IT and computing. At 58.8, construction was at the bottom of this league table, demonstrating how short-term fluctuations are having a strong impact. Nonetheless, even in construction there was a marginal increase in the number of vacancies in June. Relative demand in June 2017 for temporary/contract staff in engineering was also higher than in previous years, with the industry placing 3rd out of 9 industries, compared with 6th place in June 2016.

But while demand is rising, the number of available candidates has declined sharply. In May 2017, the REC survey registered the sharpest drop in permanent candidate numbers since August 2015. This decline continued into June, the most recent month for which data was available at the time of writing.

REC suggests the scarcity of candidates alongside rising demand has had a knock-on effect on starting salaries. Its June 2017 survey recorded starting salaries increasing at the quickest pace for the last 18 months. This appears to be supported by the latest estimates from ONS, at least in nominal (not adjusted for price inflation) terms. It shows average weekly earnings in May 2017 up 1.8% including bonuses (or 2.0% excluding bonuses) compared with a year earlier.

Out of nine job sectors in which staff demand was monitored by REC, the highest demand for permanent staff in June 2017 was in engineering (68.4, up from 61.4 in the previous year).

9.18 Recruitment and Employer Confederation. UK Labour Market: Report on Jobs, July 2017.

However, while nominal wage rises are being seen, real wages appear to be stagnant. Once adjusted for price inflation, average weekly earnings in March to May 2017 represent a 0.7% decrease including bonuses (0.5% excluding bonuses) compared with a year earlier.[9.19] The Bank of England's Inflation Report in May 2017 downgraded its forecast of average weekly earnings, projecting a rise of just over 2% in 2017, while at the same time increasing inflation projections to 2.8% for the year.[9.20] Economists have speculated that this wage stagnation is both a consequence of the UK's low labour productivity and the inflation it has experienced since the country's decision to leave the EU.

REC suggests the scarcity of candidates alongside rising demand has had a knock-on effect on starting salaries.

9.3 – Average earnings

Full time annual gross pay by occupation and gender

Overall, the mean salary (annual gross pay) of full time employees in 2016, the latest year for which this information is available, was £34,414. This is 2.2% higher than the previous year. The median figure, which is perhaps more representative as it is unaffected by outliers, was £28,213, a 2.3% increase compared with 2015.

An analysis of individual professional and manager occupations (ONS's standard occupation classification, or SOC, codes, major groups 1 and 2) shows that there was considerable volatility in terms of pay, with both year on year falls and rises (**Figure 9.5**). Looking at some of the mainstream engineering professions (**Figure 9.6**), the median salary of civil engineers was £40,953 (up 1.7%), for mechanical engineers it was £41,808 (down 1.9%) and for electrical engineers it was £44,696 (up 3.5%). The median salary of electronics engineers saw a large annual percentage increase of 14.4% to £47, 394. Some engineering professions earned much more highly, including aircraft pilots and flight engineers (median salary of £87,570) and information technology and telecommunications directors (£69,995).

The median salary of each 'core' engineering occupation in SOC major group 1 (managers, directors and senior officials) was higher than the median salary for the SOC group as a whole (£42,250). With the exception of environmental professions and quality control and planning engineers, this was also the case for each core engineering occupation in SOC major group 2 (professional occupations).

However, while nominal wages are rising, real wages appear stagnant. This may be a consequence of both the UK's low labour productivity and the inflation it has experienced since the EU referendum.

There was also volatility in the annual gross pay for engineering occupations at the levels of associate professional and technician (SOC major group 3), skilled trades (group 5) and process, plant and machine operative (group 8) between 2015 and 2016 (**Figure 9.7**). The median salary of electrical and electronics technicians saw a large annual percentage increase of 10.0% to £32,105 as did TV, video and audio engineers (10.3% increase to £29,922) and rubber process operatives (10.3% increase to £30,644). However, others saw considerable declines in annual gross pay over the 2015 to 2016 period, including pipe fitters (down 14.4% to £33,888), precision instrument makers and repairers (down 11.0% to £25,150), rail and rolling stock builders and repairers (down 9.3% to £40,535) and water and sewerage plant operatives (down 8.9% to £27,730).

9.19 Office for National Statistics. Statistical bulletin: UK labour market: September 2017, September 2017.
9.20 Government Equalities Office and The Rt Hon Justine Greening MP. Gender Pay Gap Reporting Goes Live, April 2017.

Figure 9.5 Annual gross pay for full time employees across all SOC and within engineering SOC codes at professional occupations and above (SOC 1 and 2) by gender in 2016 – UK

		All full time				
	SOC code	No. of jobs (000's)	Median salary £	Change over 1 year (%)	Mean salary £	Change over 1 year (%)
All employees (all SOC)		**15,910**	**28,195**	**2.1% ▲**	**34,447**	**2.4% ▲**
Managers, directors and senior officials	**1**	**2,036**	**42,250**	**3.0% ▲**	**57,167**	**2.5% ▲**
Production managers and directors in manufacturing	1121	444	45,944	2.7% ▲	57,443	5.3% ▲
Production managers and directors in construction	1122	80	43,246	1.7% ▲	51,168	0.0%
Production managers and directors in mining and energy	1123	x	45,269	4.2% ▲	52,242	-2.6% ▼
Professional occupations	**2**	**3,793**	**37,690**	**1.8% ▲**	**42,347**	**1.4% ▲**
Civil engineers	2121	41	40,953	1.7% ▲	42,254	-1.1% ▼
Mechanical engineers	2122	31	41,808	-1.9% ▼	45,820	-0.3% ▼
Electrical engineers	2123	19	44,696	3.5% ▲	46,443	2.3% ▲
Electronics engineers	2124	x	47,394	14.4% ▲	49,811	6.7% ▲
Design and development engineers	2126	67	39,255	2.9% ▲	42,041	2.5% ▲
Production and process engineers	2127	39	38,684	0.9% ▲	40,320	1.2% ▲
Engineering professionals n.e.c.	2129	128	40,194	-0.5% ▼	42,534	0.4% ▲
IT business analysts, architects and systems designers	2135	89	44,778	3.4% ▲	48,752	3.5% ▲
Programmers and software development professionals	2136	164	40,689	2.5% ▲	42,916	2.6% ▲
Information technology and telecommunications professionals n.e.c.	2139	69	38,987	2.6% ▲	42,740	2.9% ▲
Environment professionals	2142	30	32,987	4.5% ▲	35,268	4.6% ▲
Research and development managers	2150	43	43,197	-3.3% ▼	51,862	-1.8% ▼
Quality control and planning engineers	2461	36	36,012	0.3% ▲	37,535	-0.1% ▼
Quality assurance and regulatory professionals	2462	66	40,964	2.5% ▲	47,796	-0.3% ▼

Source: ONS, Annual Survey of Hours and Earnings 2016
x = coefficient of variation (CV) > 20% (estimates are considered unreliable for practical purposes) – = disclosive : = not applicable
Please note: 'n.e.c' is an abbreviation for 'not elsewhere classified'
To view this table with both core and related engineering occupations and annual percentage change for male and female full time employees, see Figure 9.5 in our Excel resource.

Figure 9.6 Median annual salaries in some of the mainstream engineering professions in the UK in 2016

Electronics engineers
£47,394

IT business analysts, architects and systems designers
£44,778

Electrical engineers
£44,696

Research and development managers
£43,197

Mechanical engineers
£41,808

Quality assurance and regulatory professionals
£40,964

Civil engineers
£40,953

Programmers and software development professionals
£40,689

Engineering professionals n.e.c.
£40,194

Information technology and telecommunications professionals n.e.c.
£69,995

Design and development engineers
£39,255

⬢ Median annual salaries (£)

Source: ONS, Annual Survey of Hours and Earnings 2016

Full time male					Full time female				
No. of jobs (000’s)	Median salary £	Change over 1 year (%)	Mean salary £	Change over 1 year (%)	No. of jobs (000’s)	Median salary £	Change over 1 year (%)	Mean salary £	Change over 1 year (%)
9,649	**30,550**	**2.0% ▲**	**37,948**	**2.2% ▲**	**6,261**	**24,831**	**2.7% ▲**	**29,052**	**2.6% ▲**
1,404	**45,762**	**2.0% ▲**	**62,675**	**1.9% ▲**	**632**	**36,209**	**5.7% ▲**	**44,933**	**4.8% ▲**
365	47,043	1.6% ▲	59,244	4.3% ▲	79	39,916	9.3% ▲	49,173	10.2% ▲
74	44,637	3.1% ▲	51,907	1.5% ▲	x	33,826		42,250	
x	45,559	5.2% ▲	53,466	-0.1% ▼	x	35,113		39,960	
2,097	**40,890**	**1.8% ▲**	**46,727**	**1.2% ▲**	**1,696**	**34,841**	**1.9% ▲**	**36,931**	**1.4% ▲**
38	41,347	0.7% ▲	42,593	-1.7% ▼	x	35,548	4.9% ▲	38,121	7.3% ▲
28	42,392	-0.8% ▼	46,380	0.2% ▲	x	35,973	-4.4% ▼	39,683	-3.2% ▼
17	44,934	5.4% ▲	46,412	2.9% ▲	x	x		46,907	-7.4% ▼
x	47,992	15.5% ▲	50,072	6.0% ▲	–				
63	39,670	3.2% ▲	42,458	2.7% ▲	x	36,706	8.2% ▲	35,700	-0.2% ▼
35	39,238	1.8% ▲	41,110	1.8% ▲	x	33,284	0.5% ▲	33,409	-4.8% ▼
112	40,286	-1.8% ▲	42,956	-0.3% ▼	x	37,700	4.4% ▲	39,562	4.3% ▲
78	45,584	3.7% ▼	50,099	4.7% ▲	x	36,389	-3.7% ▼	39,267	-5.3% ▼
149	40,998	2.5% ▲	43,368	3.1% ▲	x	x		38,188	-3.9% ▼
57	40,027	-1.5% ▼	44,346	3.9% ▲	11	33,670	1.5% ▲	34,540	-3.2% ▼
22	33,793	4.9% ▲	36,492	5.9% ▲	8	27,320	-3.7% ▼	31,768	1.4% ▲
30	45,058	-1.9% ▼	54,301	-4.3% ▼	13	40,546	2.7% ▲	46,340	8.0% ▲
29	36,224	0.8% ▲	38,295	1.3% ▲	6	34,167	-4.5% ▼	34,041	-5.8% ▼
41	42,384	1.2% ▲	51,324	-1.1% ▼	25	38,166	2.0% ▲	42,078	1.2% ▲

Production and process engineers

£38,684

Quality control and planning engineers

£36,012

Environment professionals

£32,987

Figure 9.7 Annual gross pay for full time employees across all SOC and within engineering SOC codes at the associate professional and technician, skilled trades, and process, plant and machine operative levels (SOC 3 to 8) by gender (2016) – UK

		All full time				
	SOC code	No. of jobs (000's)	Median salary £	Change over 1 year (%)	Mean salary £	Change over 1 year (%)
All employees (all SOC)		**15,910**	**28,195**	**2.1% ▲**	**34,447**	**2.4% ▲**
Associate professional and technical occupations	**3**	**2,707**	**31,484**	**0.2% ▲**	**36,716**	**0.1% ▲**
Electrical and electronics technicians	3112	9	32,105	10.0% ▲	31,973	6.5% ▲
Engineering technicians	3113	69	34,950	1.5% ▲	36,506	1.0% ▲
Building and civil engineering technicians	3114	x	29,850	2.9% ▲	31,414	3.4% ▲
Quality assurance technicians	3115	25	25,698	-4.7% ▼	27,881	-2.3% ▼
Planning, process and production technicians	3116	31	29,355	-2.5% ▼	31,824	-3.9% ▼
Science, engineering and production technicians n.e.c.	3119	108	26,311	0.3% ▲	28,064	0.1% ▲
Draughtspersons	3122	29	28,784	3.0% ▲	31,371	1.6% ▲
Inspectors of standards and regulations	3565	14	31,404	6.2% ▲	32,659	2.0% ▲
Skilled trades occupations	**5**	**1,566**	**26,056**	**1.7% ▲**	**27,912**	**2.1% ▲**
Sheet metal workers	5213	12	25,189	7.2% ▲	26,713	-0.8% ▼
Metal plate workers, and riveters	5214	x	28,717	-2.2% ▼	31,472	1.5% ▲
Welding trades	5215	40	24,638	-3.0% ▼	27,247	-2.7% ▼
Pipe fitters	5216	x	33,888	-14.4 ▼	34,720	-12.1% ▼
Metal machining setters and setter-operators	5221	55	25,891	-1.2% ▼	27,676	-1.2% ▼
Tool makers, tool fitters and markers-out	5222	8	27,913	5.5% ▲	29,548	7.3% ▲
Metal working production and maintenance fitters	5223	288	30,396	3.9% ▲	32,192	4.2% ▲
Precision instrument makers and repairers	5224	11	25,150	-11.0% ▼	28,259	-4.3% ▼
Air-conditioning and refrigeration engineers	5225	x	32,342	3.3% ▲	33,866	5.6% ▲
Vehicle technicians, mechanics and electricians	5231	106	25,941	3.7% ▲	26,988	5.0% ▲
Vehicle body builders and repairers	5232	20	25,203	0.6% ▲	26,761	1.0% ▲
Aircraft maintenance and related trades	5235	14	34,104	1.8% ▲	35,737	3.9% ▲
Rail and rolling stock builders and repairers	5237	x	40,535	-9.3% ▼	44,204	-5.0% ▼
Electricians and electrical fitters	5241	118	30,769	1.2% ▲	31,577	0.6% ▲
Telecommunications engineers	5242	33	32,071	0.4% ▲	34,001	1.0% ▲
TV, video and audio engineers	5244	x	29,922	10.3% ▲	29,871	4.9% ▲
IT engineers	5245	13	27,248	2.8% ▲	30,944	5.6% ▲
Electrical and electronic trades n.e.c.	5249	110	31,029	5.5% ▲	32,610	2.9% ▲
Skilled metal, electrical and electronic trades supervisors	5250	41	33,031	0.9% ▲	36,375	1.0% ▲
Plumbers and heating and ventilating engineers	5314	47	28,566	-2.0% ▼	29,238	1.8% ▲
Construction and building trades supervisors	5330	37	33,806	3.9% ▲	35,483	2.4% ▲
Process, plant and machine operatives	**8**	**1,179**	**23,782**	**2.3% ▲**	**25,534**	**2.1% ▲**
Rubber process operatives	8115	x	30,644	10.3% ▲	28,665	5.2% ▲
Plastics process operatives	8116	11	22,407	0.2% ▲	24,916	0.5% ▲
Metal making and treating process operatives	8117	8	24,500	-0.5% ▼	25,930	-3.1% ▼
Paper and wood machine operatives	8121	20	19,544	1.4% ▲	21,433	1.5% ▲
Coal mine operatives	8122	x	29,963	0.1% ▲	32,820	-5.5% ▼
Quarry workers and related operatives	8123	x	32,266	8.8% ▲	33,676	1.2% ▲
Metal working machine operatives	8125	18	21,352	4.1% ▲	22,974	2.0% ▲
Water and sewerage plant operatives	8126	9	27,730	-8.9% ▼	28,438	-8.8% ▼
Plant and machine operatives n.e.c.	8129	10	23,704	3.3% ▲	26,756	5.4% ▲
Routine inspectors and testers	8133	46	23,516	4.4% ▲	25,077	2.0% ▲
Rail construction and maintenance operatives	8143	8	30,574	-7.6% ▼	32,322	-7.7% ▼

Source: ONS, Annual Survey of Hours and Earnings 2016
Due to low numbers resulting in suppressions, data for SOC 5211, 5212, and 5236 are not presented here.

Full time male					Full time female				
No. of jobs (000's)	Median salary £	Change over 1 year (%)	Mean salary £	Change over 1 year (%)	No. of jobs (000's)	Median salary £	Change over 1 year (%)	Mean salary £	Change over 1 year (%)
9,649	**30,550**	**2.0% ▲**	**37,948**	**2.2% ▲**	**6,261**	**24,831**	**2.7% ▲**	**29,052**	**2.6% ▲**
1,664	**34,000**	**0.3% ▲**	**39,939**	**0.5% ▲**	**1,044**	**28,024**	**0.3% ▲**	**31,580**	**0.1% ▲**
9	32,516	9.2% ▲	32,525	6.4% ▲	x	x		x	
63	35,399	0.9% ▲	36,594	0.3% ▲	6	31,273	5.7% ▲	35,652	7.7% ▲
x	29,900	4.1% ▲	32,182	5.0% ▲	x	26,488	-8.2% ▼	28,472	-2.7% ▼
16	26,775	-2.2% ▼	28,992	-0.8% ▼	9	24,500	-5.3% ▼	25,765	-5.4% ▼
23	30,961	-3.3% ▼	33,895	-5.1% ▼	x	x		x	
94	26,923	0.2% ▲	28,802	0.1% ▲	14	20,817	-3.9% ▼	23,014	1.0% ▲
25	29,374	5.3% ▲	32,111	3.1% ▲	x	x		x	
12	31,992	4.3% ▲	33,704	2.7% ▲	x	29,379	10.2% ▲	28,397	-3.7% ▼
1,447	**26,681**	**2.1% ▲**	**28,494**	**2.2% ▲**	**119**	**18,652**	**3.9% ▲**	**20,829**	**3.2% ▲**
11	25,375	7.4% ▲	26,893	-0.8% ▼	–				
x	28,717	-2.2% ▼	31,472	1.5% ▲	:				
39	24,742	-2.8% ▼	27,423	-2.5% ▼	–				
x	33,888	-14.4% ▼	34,720	-12.1% ▼	:				
53	26,148	-1.6% ▼	27,834	-1.5% ▼	x	x		21,029	3.7% ▲
8	27,913	5.0% ▲	29,548	6.3% ▲	:				
280	30,519	3.7% ▲	32,254	3.8% ▲	9	24,276		30,216	27.9% ▲
9	25,308	-13.1% ▼	28,886	-3.0% ▼	x	x		24,816	
x	32,342	3.3% ▲	33,866	5.6% ▲	:				
105	26,077	4.2% ▲	27,045	4.7% ▲	x	x		21,161	15.8% ▲
19	25,405	1.0% ▲	26,819	0.9% ▲	–				
14	34,067	1.5% ▲	35,731	2.5% ▲	–				
x	39,773	-9.3% ▼	43,787	-5.6% ▼	–				
117	30,801	1.4% ▲	31,623	0.7% ▲	x	x		x	
32	32,499	1.4% ▲	34,069	0.5% ▲	x	28,568	8.1% ▲	31,600	25.4% ▲
x	29,985	9.6% ▲	30,126	5.5% ▲	–				
12	26,924	1.6% ▲	30,769	6.6% ▲	x	x		x	
107	31,033	5.7% ▲	32,561	3.0% ▲	x	30,256	-4.7% ▼	34,329	0.7% ▲
40	33,031	0.8% ▲	36,382	0.5% ▲	x	32,264	14.0% ▲	36,203	10.3% ▲
47	28,461	-2.4% ▼	29,269	1.5% ▲	x	x		x	
37	33,914	4.0% ▲	35,621	2.3% ▲	x	26,120		26,762	7.8% ▲
1,048	**24,761**	**1.6% ▲**	**26,279**	**1.4% ▲**	**131**	**17,700**	**4.5% ▲**	**19,577**	**3.4% ▲**
x	31,246	4.1% ▲	29,281	1.2% ▲	–				
10	22,492	0.1% ▲	25,367	-0.4% ▼	x	x		19,774	-1.3% ▼
8	24,500	-0.5% ▼	25,930	-3.1% ▼	:				
18	20,187	0.4% ▲	21,891	1.0% ▲	x	16,286	8.1% ▲	16,509	0.6% ▲
x	29,963	0.1% ▲	32,820	-5.5% ▼	:				
x	33,332	11.2% ▲	34,937	3.2% ▲	–				
15	22,092	3.9% ▲	23,672	1.7% ▲	x	18,344	2.1% ▲	18,537	-2.4% ▼
9	27,783	-8.9% ▼	29,044	-8.6% ▼	x	x		x	
9	24,177	0.5% ▲	27,385	5.9% ▲	x	x		21,972	1.7% ▲
33	25,269	-0.4% ▲	26,573	-0.6% ▼	13	20,166	9.1% ▲	21,328	8.7% ▲
7	30,542	-10.8% ▼	32,386	-8.6% ▼	x	x		31,523	5.9% ▲

To view this table with core/related engineering occupations and annual percentage change for male/female full time employees, see Figure 9.7 in our Excel resource.
x = coefficient of variation (CV) > 20% (estimates are considered unreliable for practical purposes) – = disclosive : = not applicable
Please note 'nec' is an abbreviation for not elsewhere classified

The gap in starting salaries between men and women who have studied science, technology, engineering and mathematics (STEM) subjects, and who go on to take jobs in these sectors, is smaller than among other professions.

Across all employees working full time, men earned more on average than women, with differences of £5,719 and £8,896 in their median and mean salaries, respectively. This trend was also observed among core engineering occupations for which there was either median or mean salary data available for male and female full time employees. In only 2 of the SOC 'core engineering' occupational groups was the average full time salary higher for women than for men. This was for electrical engineers (with women earning a mean salary of £46,907 compared with £46,412 for men – a £495 difference) and electrical and electronic trades not elsewhere classified (with women earning a mean salary of £34,329 compared with £32,561 – a £1,768 difference).

However, there were only 7 'core' engineering occupations in which the gender difference in median salary was larger for the occupation than it was for the SOC major group that the occupation belonged to. When looking at mean salaries, this was only the case for 3 'core' engineering occupations. This suggests that although there is a gender pay gap in engineering, it is generally smaller than observed more widely in the workforce. Research by Deloitte similarly suggests that the gap in starting salaries between men and women who have studied science, technology, engineering and mathematics (STEM) subjects, and who go on to take jobs in these sectors, is smaller than among other professions.[9.21]

Nevertheless, it remains that in almost all cases where gender pay gap among engineering occupations exceeded that found in the SOC major group, these were at SOC 1 and 2. This implies that gender pay differences within engineering occupations may be a particular issue at higher levels ie. managerial, director, and senior roles (SOC 1) and professional occupations (SOC 2).

Interpreting gender pay gap data

While gross annual pay data presented here suggests evidence of a gender pay gap, it should be interpreted with a degree of caution. This is because these figures are averages from a range of salaries for different jobs, grouped under occupational headings. A difference by gender for an occupation could be the result of more women being employed at lower level – and thus lower paid – jobs, and should not be taken as evidence of unequal pay.

Part time annual gross pay by occupation and gender

Figure 9.8 and Figure 9.9 show size and pay data for part time employees in a selection of STEM occupations at professional level. The numbers employed on this basis within individual occupations are not always large enough to be available, and as a result, in many of these instances median salary information has been suppressed. Discussion of part time pay will therefore be primarily in terms of mean salaries.

Part time workers in 2016 earned a mean salary of £11,953 and a median salary of £9,616, an increase of 4.2% and 4.1% respectively compared with 2015. In many STEM occupations there were relatively well paid part time roles, with average salaries close to many full time graduate starting salaries. Of the 27 part time core engineering occupations for which data was available, the mean salary of 18 was higher than the mean salary for its respective SOC major group.

There was considerable volatility in terms of pay, though this may be in part due to the relatively small numbers of employees working within certain occupations. In 2016, some part time mean salaries were considerably lower than in 2015. These included production and process engineers (down 15.0%), vehicle body builders and repairers (down 24.2%), and plastics process operatives (down 26.3%) and metal making and treatment process operatives (down 51.9 %). In the same period, however, mean salaries increased for those working part time in welding trades (up by 25.9%), vehicle technicians, mechanics and electricians (up by 10.4%), and metal working machine operatives (up by 14.0%).

9.21 Deloitte. Deloitte analysis: without action gender pay gap won't close until 2069, September 2016.

Figure 9.8 Annual gross pay in 2016 for part time employees across all SOC and within core engineering occupations (SOC 1 to 3) by gender – UK

		All part time			Part time male		Part time female	
	SOC code	No. of jobs (000's)	Mean salary £	Change over 1 year (%)	No. of jobs (000's)	Mean salary £	No. of jobs (000's)	Mean salary £
All employees (all SOC)		**5,975**	**11,953**	**4.2% ▲**	**1,355**	**12,988**	**4,620**	**11,649**
Managers, directors and senior officials	**1**	**271**	**18,951**	**2.9% ▲**	**114**	**18,720**	**157**	**19,119**
Production managers and directors in manufacturing	1121	60	15,850	8.3% ▲	37	14,601	23	17,918
Production managers and directors in construction	1122	7	x		x	x	x	x
Production managers and directors in mining and energy	1123	:			:		:	
Professional occupations	**2**	**1,022**	**20,761**	**2.0% ▲**	**222**	**22,601**	**800**	**20,251**
Civil engineers	2121	x	x		x	x	x	x
Mechanical engineers	2122	x	30,360		x	x	x	41,909
Electrical engineers	2123	–			–		:	
Electronics engineers	2124	–			:		–	
Design and development engineers	2126	x	25,785		x	x	x	33,409
Production and process engineers	2127	x	24,218	-15.0% ▼	–		x	25,166
Engineering professionals n.e.c.	2129	x	24,193	-5.6% ▼	x	x	x	26,845
IT business analysts, architects and systems designers	2135	x	25,968	1.1% ▲	x	27,512	x	24,005
Programmers and software development professionals	2136	10	20,446	-7.7% ▼	x	18,933	x	23,556
Information technology and telecommunications professionals n.e.c.	2139	x	14,688		x	x	x	19,247
Environment professionals	2142	x	25,008		x	26,446	x	23,463
Research and development managers	2150	x	26,390		x	28,603	x	25,270
Quality control and planning engineers	2461	x	20,333	2.2% ▲	x	20,898	x	18,931
Quality assurance and regulatory professionals	2462	x	27,533	5.5% ▲	x	x	x	26,653
Associate professional and technical occupations	**3**	**412**	**15,187**	**1.6% ▲**	**96**	**15,598**	**316**	**15,062**
Electrical and electronics technicians	3112	x	x		x	x	:	
Engineering technicians	3113	x	16,101		x	x	x	15,881
Building and civil engineering technicians	3114	–			–		–	
Quality assurance technicians	3115	x	16,930		x	15,757	x	x
Planning, process and production technicians	3116	x	x		–		x	15,581
Science, engineering and production technicians n.e.c.	3119	8	13,984	2.0% ▲	x	15,001	x	13,369
Draughtspersons	3122	x	x		x	10,548	x	x
Inspectors of standards and regulations	3565	x	18,252		x	x	x	15,652

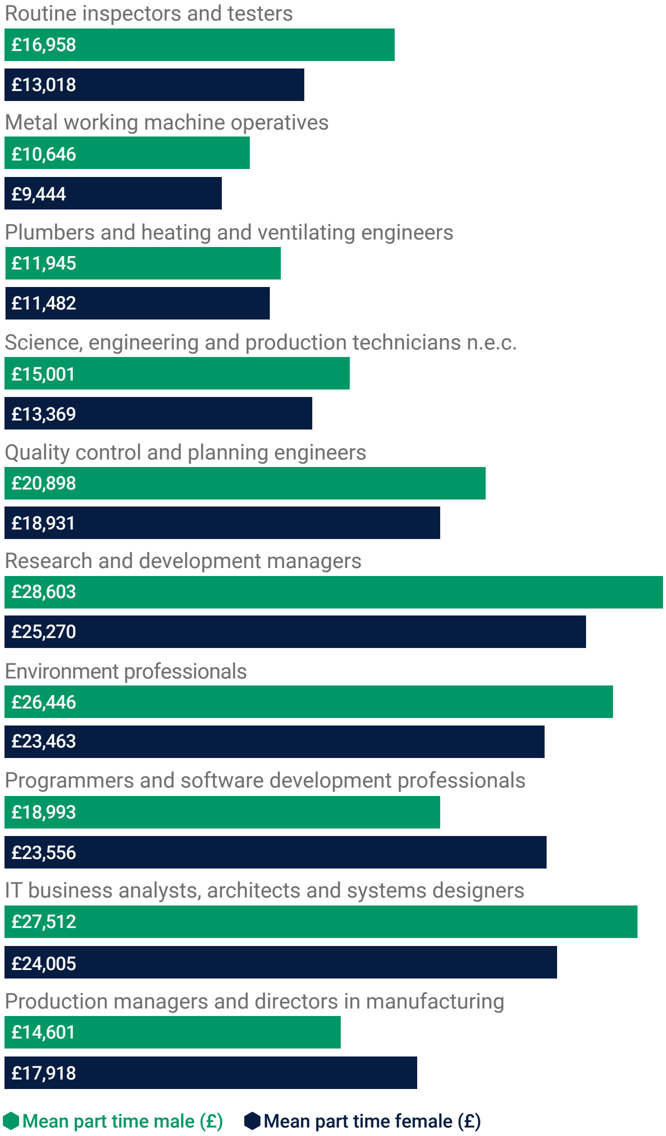
Source: ONS, Annual Survey of Hours and Earnings 2016
x = coefficient of variation (CV) > 20% (estimates are considered unreliable for practical purposes) – = disclosive : = not applicable
Please note: 'n.e.c' is an abbreviation for 'not elsewhere classified'
To view this table with core/related engineering occupations and annual percentage change for male and female part time employees, see Figure 9.8 in our Excel resource.

Figure 9.9 Annual gross pay in 2016 for part time employees across all SOC and within core engineering occupations (SOC 5 and 8) by gender – UK

		All part time			Part time male		Part time female	
	SOC code	No. of jobs (000's)	Mean salary £	Change over 1 year (%)	No. of jobs (000's)	Mean salary £	No. of jobs (000's)	Mean salary £
All employees (all SOC)		**5,975**	**11,953**	**4.2% ▲**	**1,355**	**12,988**	**4,620**	**11,649**
Skilled trades occupations	**5**	**175**	**11,761**	**5.6% ▲**	**100**	**13,166**	**75**	**9,869**
Smiths and forge workers	5211	–			:		–	
Moulders, core makers and die casters	5212	:			:		:	
Sheet metal workers	5213	–			–		:	
Metal plate workers, and riveters	5214	x	x		x	x	:	
Welding trades	5215	x	23,895	25.9% ▲	x	23,895	:	
Pipe fitters	5216	x	x		x	x	:	
Metal machining setters and setter-operators	5221	x	x		x	x	–	
Tool makers, tool fitters and markers-out	5222	x	x		x	x	:	
Metal working production and maintenance fitters	5223	10	x		9	x	x	x
Precision instrument makers and repairers	5224	–			–		:	
Air-conditioning and refrigeration engineers	5225	–			–		:	
Vehicle technicians, mechanics and electricians	5231	x	13,507	10.4% ▲	x	13,507	:	
Vehicle body builders and repairers	5232	x	8,152	-24.2% ▼	x	8,152	:	
Aircraft maintenance and related trades	5235	–			–		:	
Boat and ship builders and repairers	5236	–			–		:	
Rail and rolling stock builders and repairers	5237	:			:		:	
Electricians and electrical fitters	5241	x	18,302	-2.5% ▼	x	18,011	–	
Telecommunications engineers	5242	x	x		x	x	:	
TV, video and audio engineers	5244	x	x		–		:	
IT engineers	5245	x	x		x	x	:	
Electrical and electronic trades n.e.c.	5249	x	17,321		x	19,095	–	
Skilled metal, electrical and electronic trades supervisors	5250	x	x		–		–	
Plumbers and heating and ventilating engineers	5314	x	11,827		x	11,945	x	11,482
Construction and building trades supervisors	5330	x	x		x	x	x	x
Process, plant and machine operatives	**8**	**163**	**11,554**	**7.1% ▲**	**120**	**12,165**	**43**	**9,846**
Rubber process operatives	8115	–			–		:	
Plastics process operatives	8116	x	9,392	-26.3% ▼	:		x	9,392
Metal making and treating process operatives	8117	x	8,297	-51.9% ▼	x	8,484	–	
Paper and wood machine operatives	8121	x	12,642		x	x	x	10,161
Coal mine operatives	8122	–			–		:	
Quarry workers and related operatives	8123	–			:		–	
Metal working machine operatives	8125	x	10,285	14.0% ▲	x	10,646	x	9,444
Water and sewerage plant operatives	8126	–			–		:	
Plant and machine operatives n.e.c.	8129	x	x		x	x	x	10,779
Routine inspectors and testers	8133	x	14,601	5.1% ▲	x	16,958	x	13,018
Rail construction and maintenance operatives	8143	–			–		:	

Source: ONS, Annual Survey of Hours and Earnings 2016
x = coefficient of variation (CV) > 20% (estimates are considered unreliable for practical purposes) – = disclosive : = not applicable
Please note: 'n.e.c.' is an abbreviation for 'not elsewhere classified'
To view this table with both core and related engineering occupations and annual percentage change for male and female part time employees, see **Figure 9.9** in our Excel resource.

Figure 9.10 Mean annual gross pay in 2016 for part time employees within selected core engineering occupations by gender – UK



Source: ONS, Annual Survey of Hours and Earnings 2016
Please note: 'n.e.c' is an abbreviation for 'not elsewhere classified'
To view this chart with numbers by median salary and changes over one year, see **Figure 9.10** in our Excel resource.

The absence of data on part time salaries for many of the STEM professional occupations in the table is evidence that the numbers who work in these roles part time is small. Given that these occupations are, in general, typically dominated by men, it is significant that there is less data available for men than women for part time roles. This suggests more women work part time than men, a trend observed more broadly in the workforce overall. Across the workforce, 4,620,000 women held part time roles compared with 1,355,000 men.

Of the 10 part time core engineering occupations for which mean salary data was available for both men and women, in 2 instances the average salary was higher for women than for men (**Figure 9.10**). This was the case for production managers and directors in manufacturing (a £3,317 differential) and programmers and software development professionals (a £4,623 difference).

Women earned more than men in just two out of 10 part time core engineering occupations: production managers and directors in manufacturing (+£3,317) and programmers and software development professionals (+£4,623).

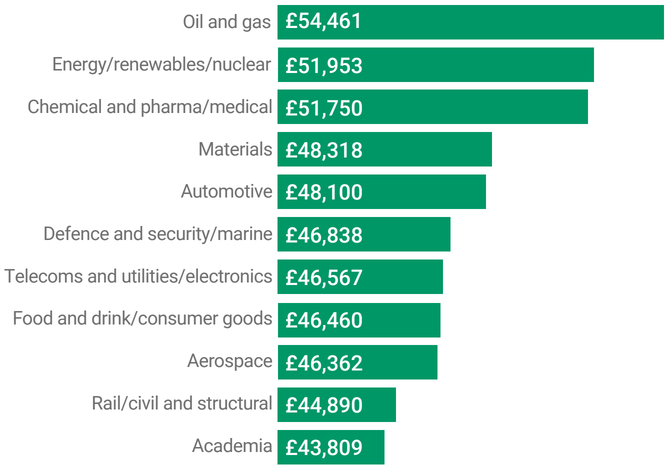
9.4 – Salary variations by industry and region

A salary survey of 2,743 UK engineers conducted by *The Engineer* in June 2017 suggests average annual earnings across engineering are £48,197.[9.22] The survey results reflect the readership of the magazine and are not necessarily representative of the wider sector (80% taking part stated they were senior managers, 93% were male, 89% were white and almost half were aged over 50). Nevertheless, they offer an insight into salary differences by region and industry.

Of the engineers surveyed by *The Engineer*, those in the oil and gas industry commanded the highest salaries, with an average of £54,461 (an increase of 6.0% from the 2016 survey). This was closely followed by those working in the energy, renewables and nuclear industry (£51,953) and the chemicals, pharmaceuticals and medical industry (£51,750) (**Figure 9.11**). Out of the 11 industries examined, academia was found to have the lowest average salary (£43,809) despite respondents within this industry being the oldest on average and highly qualified relative to others. Other engineering industries were found to be closely clustered around the overall average of £48,197, with a range of £44,890 to £48,313.

The Engineer survey shows that earnings of engineers vary considerably by industry and region (**Figure 9.12**).

Figure 9.11 Average salaries in 2017 of UK engineers working in the UK and abroad by industry



Source: The Engineer Salary Survey 2017

Figure 9.12 Average salaries in 2017 of UK engineers within the UK and outside the UK, by country/region and industry

	Midlands or East Anglia	North (England)	Scotland, Wales or Northern Ireland	South West (England)	London or South East (England)	Outside UK	Overall average salary
Academia	£48,208	£37,647	£43,800	£40,777	£50,588	£33,950	£43,809
Aerospace	£49,380	£44,340	£38,190	£45,129	£47,931	£47,697	£46,362
Automotive	£50,708	£45,950	£42,380	£43,388	£50,737	£40,802	£48,100
Chemical and pharma/medical	£50,218	£51,815	£51,250	£45,411	£56,500	£48,391	£51,750
Defence and security/marine	£46,722	£57,473	£40,583	£44,145	£47,773	£50,023	£46,838
Energy/renewables/nuclear	£49,822	£56,750	£50,782	£50,523	£49,066	£52,660	£51,953
Food and drink/consumer goods	£47,534	£46,411	£46,722	£48,703	£47,413	£40,215	£46,460
Materials	£51,071	£46,565	£45,571	£53,000	£49,076	£46,817	£48,318
Oil and gas	£43,305	£47,195	£72,480	£46,909	£56,575	£62,716	£54,461
Rail/civil and structural	£41,222	£43,500	£46,875	£48,100	£49,422	£39,582	£44,890
Telecoms and utilities/electronics	£47,246	£42,028	£40,384	£40,891	£53,300	£49,899	£46,567

Source: The Engineer Salary Survey 2017

9.22 The Engineer. 'Salary Survey 2017: Bearing up in the Brexit breeze', June 2017.

Engineers in London and the South East have overtaken those working overseas to become the highest earners in 2017, with an average salary of £51,743.[9.23] In part, this is likely to reflect the high cost of living in the capital and Home Counties. Of those working in London and the South East, engineers in the oil and gas and the chemical, pharmaceutical and medical industries commanded the highest salaries. Engineers in the South West were the lowest earners (earning an average of £45,022), despite salaries in the region increasing by over 10% since the 2016 survey (when they were £40,827). Among the engineers working outside the UK, those in the oil and gas industry achieved the highest average salary, although this has dropped to £62,716 from £67,924 in 2016.

An analysis of annual mean salaries by occupation and region shows similar variations. Employees working in London had the highest annual mean earnings across all occupations, at £48,059 for employees working full time and £15,305 for those working part time (**Figure 9.13** and **Figure 9.14**). However, mean earnings for some engineering occupations were higher outside London. For example, civil engineers, electrical engineers and IT engineers earned most on average in the South East, sheet metal workers and electrical and electronics technicians earned most in the East of England, and paper and wood machine operatives earned most in Scotland.

Engineers in the oil and gas industry commanded the highest salaries, with an average of £54,461.

Earnings comparisons take no account of regional variations in prices for goods and services and therefore don't necessarily indicate differences in the standard of living. Neither do they take account of differences in the regional composition of the workforce, so like-for-like comparisons may not be appropriate. For example, a region might have a lower level of median earnings than another because it has a higher proportion of employees in industries or occupations with relatively low earnings.

The variations in the data by region and occupational role reflect the complexity of the local labour market and the varying needs for high level engineering-related skills by different organisations across the UK. It is clear, though, that engineering occupations offer the potential to earn good salaries right across the UK.

With an average salary of £51,743, engineers in London and the South East have overtaken those working overseas to become the highest earners in 2017.

Figure 9.13 Annual gross pay in 2016 for full time employees within core engineering occupations (SOC 1 to 3) by nation/region – UK

	SOC Code	North East	North West	Yorkshire and the Humber	East Midlands
All employees (all SOC)		**£29,574**	**£31,145**	**£29,811**	**£30,085**
Managers, directors and senior officials	**1**	**£44,629**	**£48,939**	**£44,278**	**£47,629**
Production managers and directors in manufacturing	1121	£50,107	£50,653	£49,760	£52,629
Production managers and directors in construction	1122	£48,134	£46,605	£43,864	£44,202
Production managers and directors in mining and energy	1123	£59,812			£45,592
Professional occupations	**2**	**£38,660**	**£39,537**	**£38,312**	**£39,623**
Civil engineers	2121	£34,547	£34,462	£40,461	£47,056
Mechanical engineers	2122		£47,104	£42,742	£38,555
Electrical engineers	2123		£37,079	£49,824	x
Electronics engineers	2124				
Design and development engineers	2126	£39,279	£40,680	£39,324	£38,142
Production and process engineers	2127	£39,360	£40,729	£37,417	£36,912
Engineering professionals n.e.c.	2129	£40,543	£41,793	£35,042	£39,434
IT business analysts, architects and systems designers	2135	£41,682	£42,129	£39,515	£45,242
Programmers and software development professionals	2136	£36,968	x	£36,404	£34,880
Information technology and telecommunications professionals n.e.c.	2139	£40,490	£35,629	£39,430	£34,309
Environment professionals	2142	£33,506	£39,242	£32,057	£29,493
Research and development managers	2150	x	£48,643	£43,682	£41,181
Quality control and planning engineers	2461	£30,572	£34,741	£33,500	£37,247
Quality assurance and regulatory professionals	2462	£44,246	£38,839	£39,551	£41,297
Associate professional and technical occupations	**3**	**£31,131**	**£34,158**	**£31,571**	**£32,467**
Electrical and electronics technicians	3112		£23,437	£35,246	£31,073
Engineering technicians	3113	£37,652	£36,949	£34,853	£35,215
Building and civil engineering technicians	3114		£27,845		
Quality assurance technicians	3115	£27,712	£26,358	£27,527	£27,486
Planning, process and production technicians	3116	£39,275	£32,975	£30,896	£28,730
Science, engineering and production technicians n.e.c.	3119	£27,651	£26,873	£28,007	£26,133
Draughtspersons	3122	£27,983	£27,308	£27,443	£27,280
Inspectors of standards and regulations	3565		£37,192	£34,110	£31,802

Source: ONS, Annual Survey of Hours and Earnings 2016
x = coefficient of variation (CV) > 20% (estimates are considered unreliable for practical purposes)   – = disclosive   : = not applicable
To view this table with both core/related data, see Figure 9.13 in our Excel resource.

	West Midlands	East of England	London	South East	South West	Wales	Scotland	Northern Ireland	United Kingdom
	£31,295	**£33,026**	**£47,924**	**£35,879**	**£31,177**	**£29,150**	**£32,872**	**£30,189**	**£34,447**
	£50,108	**£49,573**	**£83,705**	**£56,587**	**£46,702**	**£41,208**	**£50,149**	**–**	**£57,167**
	£55,490	£55,330	£76,152	£58,199	£52,315	£45,541	£54,595	–	£57,443
	£47,248	£47,845	£60,445	£52,124	£52,629	£41,731	£51,768	–	£51,168
		£41,321		£49,704			x	–	£52,242
	£39,204	**£41,470**	**£50,972**	**£42,513**	**£39,696**	**£38,973**	**£41,277**	**–**	**£42,347**
	£38,131	£44,109	£41,346	£49,935	£37,741	£35,510	£44,785	–	£42,254
	£47,730	£48,394	£48,561	£43,480	£50,318	x	£50,553	–	£45,820
	£38,636	£53,246	£52,866	£54,409	£39,611		£43,589	–	£46,443
			£46,071	£51,722	£42,169			–	£49,811
	£40,549	£43,847	£55,189	x	£38,735	£38,129	£49,135	–	£42,041
	£41,337	£36,341	£43,436	£44,123	£37,646	£39,032	£41,419	–	£40,320
	£45,638	£39,749	£46,769	£42,366	£42,814	£40,565	£45,674	–	£42,534
	£42,366	£49,764	£57,624	£52,366	£47,771	£40,259	£41,392	–	£48,752
	£37,271	£44,589	£49,715	£46,028	£42,049	£36,544	£41,661	–	£42,916
	£37,137	£42,922	£49,426	£43,185	£37,705	£34,501	£45,281	–	£42,740
	£33,106	£33,239	£48,223	£37,449	£36,376	£23,382	£31,155	–	£35,268
	£56,903	£64,221	£60,819	£52,566	£41,605	£41,127	£38,745	–	£51,862
	£37,262	£39,752	£43,431	£40,182	£30,896	£31,390	£35,802	–	£37,535
	£43,654	£41,041	£67,010	£46,337	£43,199	£41,685	£46,826	–	£47,796
	£34,215	**£35,225**	**£46,630**	**£38,905**	**£33,808**	**£31,062**	**£34,992**	**–**	**£36,716**
	£33,619	£47,067	£34,324	£29,238	£34,724	£26,766	£22,907	–	£31,973
	£34,208	£37,246	£44,786	£35,548	£33,351	£37,970	£35,063	–	£36,506
	£28,793			£36,569			x	–	£31,414
	£26,716	£28,639	£31,931	£28,882	£26,671	£23,650	£30,688	–	£27,881
	£34,802	£30,819	x	£28,764	£31,054	£27,986	£38,730	–	£31,824
	£26,357	£27,761	£33,511	£30,086	£28,392	£24,882	£27,235	–	£28,064
	£33,603	£32,307	x	£37,441	£30,903	£33,217	x	–	£31,371
	£28,445		£36,921	£35,842	£35,985	£27,485	£26,354	–	£32,659

Figure 9.14 Annual gross pay in 2016 for full time employees within core engineering occupations (SOC 5 and 8) by nation/region – UK

	SOC Code	North East	North West	Yorkshire and the Humber	East Midlands
All employees (all SOC)		**£29,574**	**£31,145**	**£29,811**	**£30,085**
Skilled trades occupations	**5**	**£27,930**	**£26,953**	**£27,049**	**£27,281**
Smiths and forge workers	5211				
Moulders, core makers and die casters	5212				
Sheet metal workers	5213	£29,435		£27,046	£28,463
Metal plate workers, and riveters	5214	£33,801	£34,542	x	£28,261
Welding trades	5215	£27,053	£21,978	£26,348	£26,512
Pipe fitters	5216		£35,157		
Metal machining setters and setter-operators	5221	£28,997	£24,497	£26,934	£27,494
Tool makers, tool fitters and markers-out	5222		£31,206	£26,398	
Metal working production and maintenance fitters	5223	£31,378	£31,381	£30,443	£29,112
Precision instrument makers and repairers	5224		£24,726		£33,680
Air-conditioning and refrigeration engineers	5225		£29,811		
Vehicle technicians, mechanics and electricians	5231	£25,286	£26,872	£25,119	£25,820
Vehicle body builders and repairers	5232	£22,802	£24,656	£28,118	x
Aircraft maintenance and related trades	5235		£33,373		£39,601
Boat and ship builders and repairers	5236				
Rail and rolling stock builders and repairers	5237				
Electricians and electrical fitters	5241	£31,038	£33,107	£31,587	£31,637
Telecommunications engineers	5242	£30,789	£32,240	£33,460	£39,478
TV, video and audio engineers	5244				
IT engineers	5245		£26,180	£26,362	
Electrical and electronic trades n.e.c.	5249	£30,343	£28,088	£31,860	£33,930
Skilled metal, electrical and electronic trades supervisors	5250	£41,173	£34,426	£31,120	£34,669
Plumbers and heating and ventilating engineers	5314	£26,156	£27,802	£28,973	£27,005
Construction and building trades supervisors	5330	£34,316	£33,961	£34,645	x
Process, plant and machine operatives	**8**	**£25,242**	**£25,155**	**£25,354**	**£24,458**
Rubber process operatives	8115		£33,304		
Plastics process operatives	8116		£19,285	£16,496	£33,317
Metal making and treating process operatives	8117		£28,264	£26,409	£22,960
Paper and wood machine operatives	8121		£20,633	£23,936	£19,947
Coal mine operatives	8122				
Quarry workers and related operatives	8123	£48,276		£39,287	
Metal working machine operatives	8125	£24,370	£18,470	£23,739	£23,044
Water and sewerage plant operatives	8126	£25,236	£27,646		£34,547
Plant and machine operatives n.e.c.	8129	£22,499	£25,745	£26,650	£32,063
Routine inspectors and testers	8133	£25,815	£26,795	£26,654	£24,130
Rail construction and maintenance operatives	8143		£35,069	£40,789	£36,982

Source: ONS, Annual Survey of Hours and Earnings 2016
x = coefficient of variation (CV) > 20% (estimates are considered unreliable for practical purposes) – = disclosive : = not applicable
To view this table with both core/elated data, see **Figure 9.14** in our Excel resource.

	West Midlands	East of England	London	South East	South West	Wales	Scotland	Northern Ireland	United Kingdom
	£31,295	**£33,026**	**£47,924**	**£35,879**	**£31,177**	**£29,150**	**£32,872**	**£30,189**	**£34,447**
	£27,494	**£28,825**	**£31,478**	**£28,945**	**£26,419**	**£26,950**	**£27,821**	**–**	**£27,912**
								–	x
								–	£28,345
	£18,726	£32,539		£25,292	£26,352		x	–	£26,713
							£34,723	–	£31,472
	£26,217	£26,765	£22,780	x	£23,271	£25,334	£29,844	–	£27,247
							£49,465	–	£34,720
	£24,759	£30,531	£27,405	£31,251	£28,876	£22,075	£29,207	–	£27,676
	£26,887	£26,230		£29,591	£25,259		£39,176	–	£29,548
	£32,578	£33,498	£36,422	£33,974	£29,007	£33,625	£32,719	–	£32,192
	£30,687	£26,550	£41,137	£30,846	£20,951		£19,306	–	£28,259
				£36,532				–	£33,866
	£26,840	£26,890	£32,206	£28,799	£25,865	£23,289	£27,495	–	£26,988
	£28,307	£31,496	x	£20,558	£26,993		£28,984	–	£26,761
		x	£31,269	£41,296	£27,399	£36,055		–	£35,737
				£28,999	£31,054			–	£26,382
			£51,434				£39,075	–	£44,204
	£31,142	£32,422	£36,573	£32,723	£28,019	£25,799	£29,196	–	£31,577
	£31,777	£31,719	£36,143	£33,048	£32,352	£32,038	£37,960	–	£34,001
			£22,042	£27,703			£33,050	–	£29,871
	£27,832	x	x	£38,560	£29,959	£30,575	£27,587	–	£30,944
	£29,627	£35,064	£38,101	£32,978	£34,931	£33,837	£29,589	–	£32,610
	£35,649	£37,227	x	£35,782	x	x	£35,648	–	£36,375
	£27,392	£32,426	£38,610	£30,984	£28,547	£26,073	£27,516	–	£29,238
	£35,007	£36,707	£46,348	£34,020	£34,382	£31,318	£32,375	–	£35,483
	£26,087	**£25,435**	**£30,922**	**£26,519**	**£24,205**	**£23,296**	**£25,317**	**–**	**£25,534**
					£25,960			–	£28,665
	£21,186	£32,793		£24,094	£23,385			–	£24,916
	£26,205	£26,649		£29,437	£22,077	£29,521		–	£25,930
	£18,926	£21,361	£21,130	£22,915	£25,217	£19,446	£28,243	–	£21,433
								–	£32,820
							£30,841	–	£33,676
	£18,525	x	£30,748	£30,449	£22,075	£21,026	£26,292	–	£22,974
	£32,631	£30,309	£22,298	£29,586	£29,555		£23,307	–	£28,438
	£25,023	£27,264	£42,344	£25,799	£19,943	£37,353	£21,350	–	£26,756
	£21,659	£25,476	£30,345	£25,765	£25,022	£21,215	£24,901	–	£25,077
	£25,646	£42,150	£26,521	£29,705	£25,826		£35,387	–	£32,322

Engineering employment and skills shortages

Despite the widespread uncertainty caused by the European referendum vote in 2016, large portions of the UK's engineering industry are enjoying a boom period. Government commitments and significant capital investment from the private sector have made this country host to some of the most innovative and ambitious projects in the world.

Investment in infrastructure has created a raft of opportunities for skilled engineers, from landmark rail projects like High Speed Two (HS2) to the transformational Thames Tideway scheme, which aims to protect the River Thames from pollution for at least the next 100 years. The aerospace sector continues to grow, with back orders from Boeing and Airbus at record levels, and the energy (outside of oil and gas) and water sectors are also showing positive growth. With a national drive for renewable energy and the water sector pushing to deliver on planned works within the 5 year asset management cycle (AMP6), demand for engineers remains high.

With Brexit coming into effect and the current strength of the Euro, there is a risk that the UK talent pool will be tempted to relocate to other markets.

Skills shortages

The increase in the number of major projects coming to fruition is clearly a huge boost for the industry, but the UK continues to suffer from a chronic skills shortage. The demand for engineering expertise remains incredibly high. Historically, the UK has relied on talent from the European Union to plug any gaps, but with Brexit coming into effect, this source of skills is no longer guaranteed. What's more, with the current strength of the Euro, there is a risk that the UK talent pool will be tempted to relocate to other markets. The cutting edge automotive market in Germany, for example, offers attractive opportunities to engineers from around the world.

MATCHTECH

Grahame Carter,
Managing Director
Matchtech

Mid to senior level engineers are in particularly high demand, but in short supply. One factor contributing to this is the ageing workforce: a well-established issue within engineering that continues to permeate every sector. To help tackle this issue, companies are looking at new ways of facilitating the transfer of knowledge from older employees to younger ones and many are increasing funding for the upskilling of their existing mid-level engineers. Both approaches will need to be combined with investment in innovative talent attraction techniques to help the UK meet demand and deliver on high-profile projects.

Water is one sector in particular that faces the challenges posed by an ageing workforce. As the current 5 year cycle for managing water assets moves through its planned phases, and legislative pressure to develop better water resources increases, the demand for suitably-skilled engineering professionals grows. In particular, the water industry needs more intermediate senior design professionals, including site delivery experts and wastewater modellers. Construction is also feeling this shortfall, as it sees huge demand for skilled trades personnel and design engineers.

Technological advancements across engineering have meant that there is a growing demand for digital skills, which didn't previously exist. For example, in transport, the focus has shifted towards smart infrastructure, with the appointment of intelligent transport systems firm Dynniq on Highway England's Southwest framework. The result is that highways projects now need more people with technology-focused skills such as 4D modelling. Likewise, the rise of connected cars has created a similar demand in the automotive sector for roles such as embedded software engineers and digitally-focused technical leads. Aerospace, a rapidly modernising sector, is following a similar path. It is now at a stage where new, dynamic leadership is needed to drive true innovation and change, such as we have seen in the automotive sector. All sectors are demanding more advanced technological abilities with Building Information Modelling, 4D and modelling skills at a premium across infrastructure and construction.

56%

The majority
of engineering professionals surveyed in our Voice of the Workforce research would consider transferring to a different skill set

With major projects underway and notable skill shortages at the mid to senior level, engineers' salaries are increasing.

Impact of skills shortages

Demand for highly skilled personnel across the infrastructure sector is high. With major projects underway and notable skill shortages at the mid to senior level, engineers' salaries are increasing. There is also a move towards permanent recruitment. Traditionally, skilled engineers working as contractors have been offered more competitive pay, but in sectors driven by public spending, such as rail, the IR35 tax regulations have tightened the rules around contracting. As a result, projects like HS2, which would normally rely on the contract market, are now more open to taking on permanent staff. Engineers will continue to be in high demand as the project progresses. So we can expect to see engineers with the right skill sets capitalise on them by demanding higher salaries.

In manufacturing, pay has stagnated for skilled trades personnel (such as PCB assemblers, CNC machinists and welders) over the past 5 years. Many of these roles have been outsourced to countries including Poland and China at a lower cost, with firms unwilling to pay higher UK wages. As a result, we are seeing more of the UK workforce with these skills moving away from the manufacturing sector, which is leaving pockets of labour shortages across the UK.

Engineering firms are having to be more strategic with their recruitment, offering a more desirable employer value proposition (EVP), which extends beyond competitive salary levels.

Potential solutions to skills shortages

Engineering firms are responding to the wide-ranging skills shortages in a number of ways. With skilled professionals in such high demand, engineering firms are having to be more strategic with their recruitment, offering a more desirable employer value proposition (EVP), which extends beyond competitive salary levels. While site-based projects pose more of a challenge, engineers across sectors such as building and water are increasingly being offered more flexibility and the opportunity to work from home.

The desire to work on flagship projects
is a top reason for joining a new employer among engineers

Companies in other sectors, such as infrastructure and rail, are hinging their recruitment strategies on the project pipeline, offering potential candidates the opportunity to work on iconic, often career-defining, schemes. This approach involves reaching out to schools and universities to attract talented young people to the engineering profession. There is some fantastic work taking place to encourage young people to adopt STEM subjects. But to guarantee progression into the sector, we must inspire tomorrow's engineering workforce by highlighting the incredible achievements of UK engineers.

Arguably, the most productive and immediate solution to the resource shortage is to find ways of transferring skills between sectors to balance peaks and troughs in demand. Over half of the engineering professionals (56%) we surveyed in our Voice of the Workforce research said they would consider transferring to a different skill set, and even more (65%) would consider transferring to a different sector. Historically, employers have been insistent on experience within the same sector. However, with our departure from the European Union in motion and the future access to EU talent remaining uncertain, employers are becoming more flexible and open to transferrable skills. We are seeing people with experience in the connected car space moving across to the smart infrastructure sector and the water sector is looking at how it can upskill tunnelling engineers from the rail sector to help plug their skills gap.

Engineers are open to applying their skills to new sectors and are driven by the desire to work on flagship projects; respondents in our Voice of the Workforce survey noted this as a top reason for joining a new employer. As we approach a post-Brexit world, it is crucial that the sector adapts to the needs of the engineering workforce to maximise the potential of our existing talent pool in the UK.

65%

Just under two thirds
of engineering professionals surveyed would consider transferring to a different sector

10 - Skills supply and demand projections

124,000 engineers and technicians with core engineering skills will be required to meet per year to 2024

79,000 people with mixed application of engineering knowledge will be required to meet demand per year to 2024

Key points

Demand projections for the UK workforce

According to *Working Futures*, between 2014 and 2024, 13 million job openings will arise across the economy as a result of those who leave the labour market (replacement demand), and a further 1.8 million openings will arise as newly created jobs (expansion demand).

The net requirement projections from *Working Futures 2014-2024* reinforce the expectation toward an increasingly higher skilled labour force. Assuming the patterns of unemployment by Qualification and Credit Framework (QCF) level maintain the same hierarchy in terms of unemployment rates, by 2024 it estimated 54.1% of the workforce will have Level 4+ qualifications. This compares to 41.1% in 2014.

Demand projections for the engineering sector

A bespoke extension of *Working Futures 2014-2024* produced on EngineringUK's behalf indicates that 2.5 million job openings of any kind will arise between 2014 and 2024 across the engineering sector. This represents 17.1% of expected vacancies across all industries. Just under 10% of this is expected to be from expansion demand.

It is clear, however, that some engineering industries are constricting, while others are expanding. For example the requirement for roles in manufacturing, while sizeable, is expected to be a result of replacement demand, as its projected expansion demand is negative. Engineering industries within wholesale, retail trade and repair of motor vehicles, transport and storage, and public administration and defence are likewise expected to experience negative expansion demand.

Meanwhile, there is expected to be strong positive expansion demand in engineering enterprises relating to electricity, gas, steam, and air conditioning supply and information and communication, where it accounts for 30.5% and 30.2%, respectively, of those industries' net requirements. Positive expansion demand is also expected to be significant in engineering enterprises in the construction industry (28.6%).

Demand projections for engineering occupations

Our analysis projects an annual demand for 124,000 engineers and technicians with core engineering skills across the economy, alongside an additional requirement for 79,000 "related" roles requiring a mixed application of engineering knowledge and skill alongside other skill sets.

Altogether, this means 203,000 engineering workers with Level 3+ skills are required per year to meet expected demand (66,000 with Level 3 skills and 137,000 with Level 4+ skills).

Estimated shortfall

Given the supply of engineering talent coming from the educational pipeline through apprenticeships and higher education, we estimate there to be a shortfall of between 37,000 and 59,000 in meeting the annual demand for core engineering roles requiring Level 3+ skills. If all those we estimate to be eligible to take up graduate engineering roles did so, the shortfall of graduates would be at least 22,000; in reality, since many do not, the shortfall is significantly higher.

Altogether – when looking at total demand for Level 3+ engineering skills across core and related engineering roles more broadly – we estimate the annual shortfall to be at least 83,000, and up to 110,000.

Leaving the European Union: implications for our estimates

The UK's exit from the European Union represents a significant threat to the supply of engineering skills. A crucial assumption underpinning our potential supply calculations is that graduates of all nationalities who studied in the UK will be eligible to work in the UK. Should the eligibility for such migrants to work in the UK or the perception of the attractiveness of working in the UK reduce, our projected supply figures will likewise fall.

Furthermore, *Working Futures*' demand model is based on best available projections for the evolution of the economy and employment, and does not take into account the UK's impending withdrawal from the EU. This clearly has the scope to impact significantly on the demand side of the equation, through its impact upon engineering activity and enterprises.

The UK's position in relation to the EU places significant uncertainty on both sides of the supply and demand equation. In the face of great change, it is essential that the engineering community work to protect the flow of international talent, expand the UK supply pipeline and communicate the considerable opportunities an engineering career can afford to those already with the requisite skills.

About the data

Demand projections discussed in this chapter are based on *Working Futures 2014-2024*, a comprehensive and detailed model of the UK labour market, produced by the Warwick Institute for Employment Research (IER) and Cambridge Economics for the UK Commission for Employment and Skills (UKCES). It projects the future size and shape of the labour market by considering employment prospects by industrial sector, occupation, qualification level, gender and employment status.

For each edition of this report, EngineeringUK has commissioned Warwick IER to produce bespoke extensions of *Working Futures* for the engineering sector.

As a result of UKCES closing in March 2017, it is uncertain whether further updates of *Working Futures* will take place. Figures reported in this chapter are therefore based on the extension of *Working Futures 2014-2024*, though they have been updated to reflect the revised engineering footprint and our refined demand methodology.

Changes and comparability

Demand, supply and shortfall figures presented in this report are not directly comparable to previous editions. This is due to the use of a revised engineering footprint, which has resulted in a narrowing of what are considered to be engineering roles and engineering industries, alongside refinement in the demand and supply methodology, such as the inclusion of forecast demand arising in the non engineering sector and the use of domicile-specific employment rates.

These changes aim to foster greater consistency in the sector going forward and take into account the considerable need for engineering skills outside of industries traditionally deemed to be engineering.

More information about how we have calculated demand and supply is provided in their respective sections within this chapter.

Demand, supply and shortfall figures presented are not directly comparable to those in previous reports. This is due to the use of a revised engineering footprint, alongside a refined demand and supply methodology.

10.1– Demand projections for the UK workforce

Terminology

Replacement demand: the number of openings created by people leaving the labour market on a temporary basis (such as maternity leave, emigration, incapacity, redundancy, unemployment, or sickness) and those retiring or dying.

Replacement demand typically represents around 2-4% per annum of the employed workforce. However, these rates can vary significantly at a more micro level. For instance, a sector with an older age profile will usually have higher replacement needs than a younger one.

Expansion demand: the net change in employment levels. When this is positive, this indicates the number of job openings as a result of growth in the sector or occupation. However, in many cases this may be negative, indicating constriction. For this reason, *Working Futures* suggests that a better term might be 'structural demand.' However, because 'expansion demand' is more commonly used, we use this term throughout the chapter.

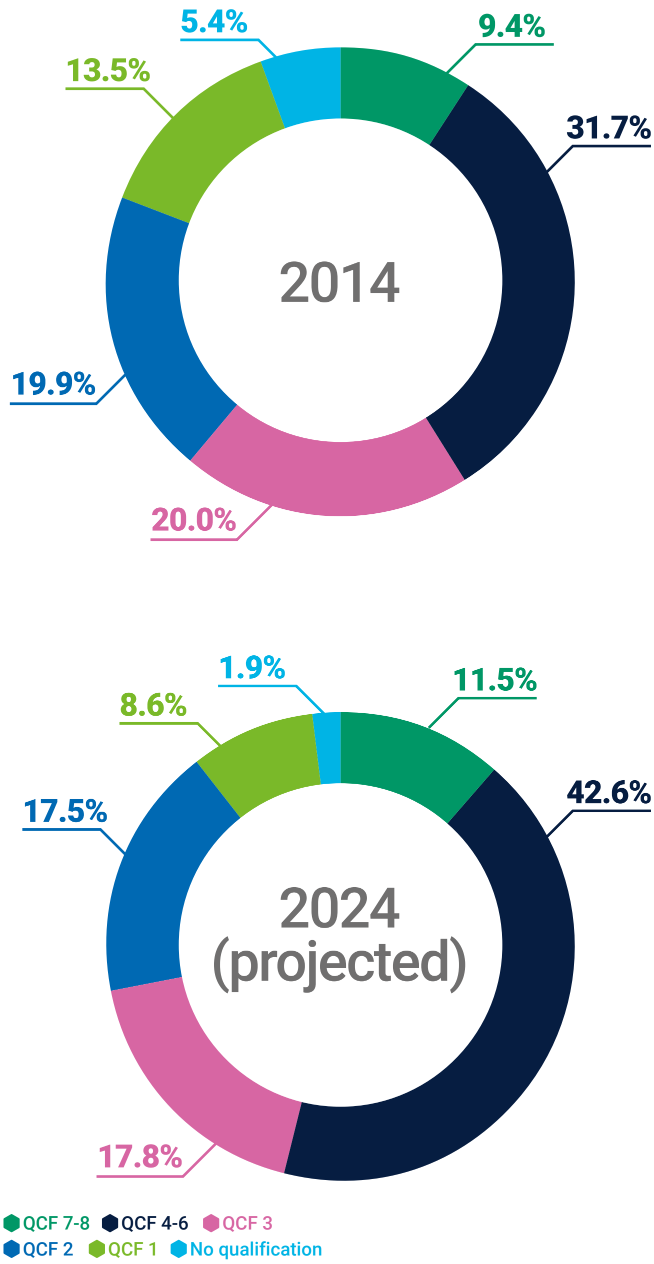
Net requirement: the sum of expansion demand and replacement demand is referred to as the net requirement. This is the overall demand expected, given both growth/ decline in the number of jobs available ('expansion demand'), and projected numbers leaving the labour market either temporarily or permanently ('replacement demand').

Demand projections by qualification level

The world of work is changing, with a growing trend in economically developed countries toward an hourglass shaped economy. Technological advances have been key to this transformation, resulting in the expansion of knowledge-intensive services and increased demand for highly skilled labour.

According to *Working Futures 2014-2024*, some 13 million job openings will arise across the economy between 2014 and 2024 as a result of those who leave the labour market (replacement demand). A further 1.8 million newly created jobs (expansion demand) are also projected in this time period. Assuming the patterns of unemployment by qualifications and credit framework (QCF) level maintain the same hierarchy in terms of unemployment rates, by 2024 it estimated 54.1% of the workforce will have qualifications Level 4 and above (**Figure 10.1**). This compares to 41.1% in 2014.

Figure 10.1 Composition of the 2014 and 2024 labour force, by qualification level – UK



Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)
QCF is an abbreviation for Qualification and Credit Framework. This framework defines formal qualifications by their level (i.e. level of difficulty) and credit value (how much time the average learner would take to complete the qualification). QCF 1 equates to GCSE grades D-G, QCF 2 to GCSE Grades A-C, and QCF 3 to A-level or equivalent. QCF4-6 refer to foundation degrees, HNCs, HNDs, and university degrees, while QCF7-8 to postgraduate level qualifications.

As **Figure 10.2** shows, the net requirement between 2014 and 2024 is projected to be heavily skewed towards roles with higher qualifications, with positive expansion demand – that is, an increase in jobs due to growth – expected only for those requiring Level 4 and above.

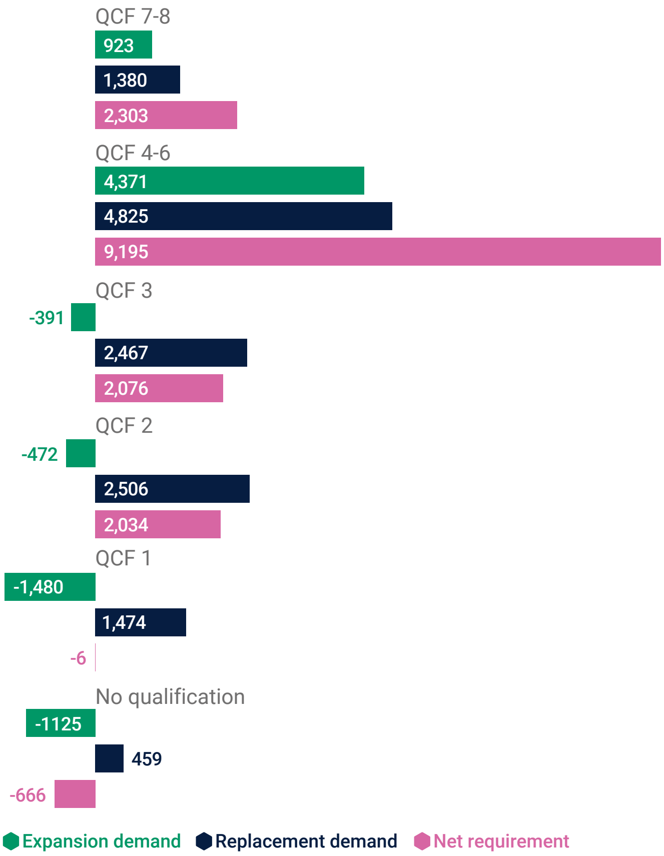
This has clear implications, highlighting the need to cultivate the skills of those who will enter the labour force in the future. It also underscores the need to up-skill the current UK workforce. Up to 90% of the current workforce will still be in work in the next decade, and longer life expectancies mean workers are increasingly expecting to stay in work for longer.[10.1,10.2]

As the government's recent industrial strategy notes, "the accelerating pace of technology change means there is a growing challenge with lifelong learning: supporting people to up-skill and re-skill across their working lives. People are living and working longer, but training across working life is going down."[10.3] Action to improve the skills and productivity of the labour force must therefore consider how to foster the rights skills both through the educational pipeline and those who are already in work.

The projected net requirement for the UK workforce is heavily skewed towards roles with higher qualifications, with positive expansion demands only for those Level 4 and above.

10.1 UKCES. 'Growth through people', November 2014.
10.2 Altman, R. 'A new vision for older workers: retain, retrain, recruit', 2015.
10.3 HM Government. 'Building our industrial strategy: green paper', January 2017. p. 40.

Figure 10.2 Projected net requirement in all industries for the period 2014 to 2024, by expansion/replacement demand and qualification level – UK



Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)
QCF is an abbreviation for Qualification and Credit Framework. This framework defines formal qualifications by their level (i.e. level of difficulty) and credit value (how much time the average learner would take to complete the qualification). QCF 1 equates to GCSE grades D-G, QCF 2 to GCSE Grades A-C, and QCF 3 to A-level or equivalent. QCF4-6 refer to foundation degrees, HNCs, HNDs, and university degrees, while QCF7-8 to postgraduate level qualifications.

Demand projections by occupational group

Across all industries, in 11 of the 25 major occupational groups there is expected to be positive expansion demand of at least 10% between 2014 and 2024 (**Figure 10.3**). These include several key service occupations and a range of professional occupations, as well as corporate managers and directors. The professional occupational roles expected to grow by this extent include those in science, research, engineering and technology along with health, teaching, business, media and public services. Skilled construction and building trades occupations and science, engineering and technology associate professional roles are also expected to grow at or above the overall rate of growth in employment.

In contrast, several occupational groups are expected to shrink over this period, most notably secretarial and related occupations (-34.4% expansion demand), but also process, plant and machine operatives (-17.1%); skilled metal, electrical and electronic trades (-9.5%); textiles, printing and other skilled trades (-8.9%); sales occupations (-5.0%); administrative occupations (-4.1%); and protective service occupations (-3.4%).

It is clear when considering net requirements as a proportion of base employment that in some occupational groups, particularly high numbers of STEM workers will be needed to fulfil demand. Between 2014 and 2024, for example, the net requirement for science, research, engineering and technology professionals represents 43.6% of the base employment in 2014. Likewise, the net requirement for skilled construction and building trades is 40.5% of the base employment and 35.9% for the science, engineering and technology associate professionals. It must be noted that this includes replacement demand – in other words, the requirement to fill jobs that have become vacant due to people leaving the labour force. Nevertheless, it provides an indication of the significant requirement for such roles going forward.

For some occupations, the need is higher still. For instance, the net requirement for health professionals and teachers is around 55% of base employment, and 59.8% for caring occupations. These projections clearly demonstrate the expected hollowing out of the middle levels of employment in favour of both highly-skilled and managerial roles and relatively low-skilled service-based roles – in other words, a movement toward the 'hourglass' economy detailed in **Chapter 1**.

Figure 10.3 Projected net requirement in all industries for the period 2014 to 2024, by expansion/replacement demand and occupational group – UK

		Expansion demand		Replacement demand		Net requirement	
	Base employment (2014) (000's)	No. (000's)	% of base employment	No. (000's)	% of base employment	No. (000's)	% of base employment
11 Corporate managers and directors	2,194	381	17.4%	841	38.3%	1,222	55.7%
12 Other managers and proprietors	1,110	118	10.6%	548	49.4%	666	60.0%
21 Science, research, engineering and technology professionals	1,712	218	12.7%	529	30.9%	747	43.6%
22 Health professionals	1,435	207	14.5%	588	40.9%	795	55.4%
23 Teaching and educational professionals	1,686	171	10.1%	750	44.5%	920	54.6%
24 Business, media and public service professionals	1,763	279	15.8%	764	43.4%	1,043	59.2%
31 Science, engineering and technology associate professionals	575	30	5.3%	176	30.6%	206	35.9%
32 Health and social care associate professionals	489	77	15.7%	191	39.1%	267	54.8%
33 Protective service occupations	376	-13	-3.4%	92	24.4%	79	21.0%
34 Culture, media and sports occupations	738	95	12.9%	318	43.1%	413	56.0%
35 Business and public service associate professionals	2,459	349	14.2%	947	38.5%	1,295	52.7%
41 Administrative occupations	2,762	-113	-4.1%	1,156	41.8%	1,042	37.7%
42 Secretarial and related occupations	804	-276	-34.4%	348	43.3%	72	9.0%
51 Skilled agricultural and related trades	419	13	3.2%	236	56.4%	249	59.6%
52 Skilled metal, electrical and electronic trades	1,258	-119	-9.5%	374	29.8%	255	20.3%
53 Skilled construction and building trades	1,176	76	6.5%	399	34.0%	476	40.5%
54 Textiles, printing and other skilled trades	760	-68	-8.9%	290	38.2%	222	29.2%
61 Caring personal service occupations	2,464	394	16.0%	1,080	43.8%	1,473	59.8%
62 Leisure, travel and related personal service occupations	670	15	2.3%	307	45.8%	322	48.1%
71 Sales occupations	2,014	-101	-5.0%	740	36.8%	639	31.7%
72 Customer service occupations	586	104	17.8%	206	35.2%	310	53.0%
81 Process, plant and machine operatives	904	-154	-17.1%	266	29.5%	112	12.4%
82 Transport and mobile machine drivers and operatives	1,163	23	2.0%	509	43.8%	532	45.8%
91 Elementary trades and related occupations	584	6	0.9%	200	34.3%	206	35.2%
92 Elementary administration and service occupations	3,068	114	3.7%	1,254	40.9%	1,368	44.6%
All occupations	**33,167**	**1,825**	**5.5%**	**13,110**	**39.5%**	**14,936**	**45.0%**

Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

10.2 – Demand projections for all jobs in the engineering sector

Changes to the engineering footprint

In conjunction with Engineering Council and the Royal Academy of Engineering, EngineeringUK reviewed and agreed a revised engineering footprint to cover an agreed list of standard occupational classification (SOC) codes and standard industrial classification (SIC) codes. Each SOC and SIC code was considered against an agreed set of rules, and advice sought from the relevant professional engineering institution where necessary.

As a result, 10 job titles were removed from the footprint, three were added and four remained with input from external organisations. Fourteen industries were removed from the list of SICs and two were added.

The three organisations agreed to in the first instance take a binary approach (ie. consider any SOC and SIC to be wholly 'in' or 'out' of the footprint). SOC codes were further classified into **core** or **related** jobs. These were defined as follows:

- **Core engineering jobs**: engineering-based roles that require the consistent application of engineering knowledge and skills to execute the role effectively e.g. production and process engineer.
- **Related engineering jobs**: those that require a mixed application of engineering knowledge and skill alongside other skill sets, which are often of greater importance to executing the role effectively e.g. architect.

More detail on these changes is provided in Chapter 2. A full list of the SOC and SIC codes included in the engineering footprint can be found in the Annex of this report.

2.5 million job openings (of all types) across the engineering sector are projected to arise between 2014 and 2024, representing 17.1% of expected vacancies across all industries.

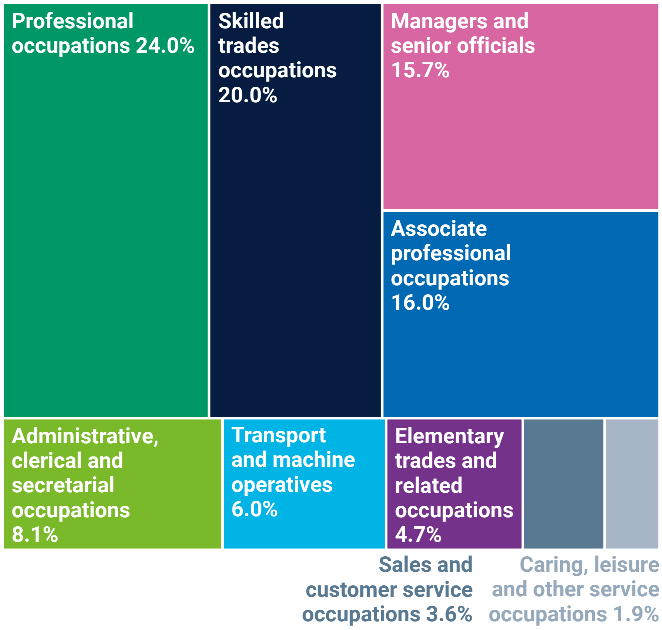
As we highlighted in **Chapter 7**, the engineering sector – that is, those industries that relate to engineering (our 'sectoral' footprint, based on SIC codes) – constitutes a significant part of the UK economy, and this fact is no less apparent when examining forecasted demand. A bespoke extension of *Working Futures 2014-2024* produced on EngineringUK's behalf indicates that 2,554,610 job openings (of all types) across the engineering sector will arise between 2014 and 2024, representing 17.1% of expected vacancies across all industries. Of these 2.5 million job openings, around 2.3 million – or 90.3% – will be to replace workers who are leaving the workforce (replacement demand), while the remaining quarter of a million will be new jobs (expansion demand).

Demand projections for the engineering sector by occupational group and qualification level

Figure 10.5 shows the projected demand for engineering jobs by both major SOC occupation group and qualification level. Following ONS guidance, corporate managers and directors and all minor groups within SOC major group 2 (professional occupations) were categorised as requiring Level 4 skills and above; skilled trades occupations Level 3; SOC major groups 4 through 8 Level 2; and elementary occupations Level 1.[10.4] In consideration of the fact that a mixture of Level 3 and 4 skills may be required for occupations within SOC major group 3 (professional occupations) and within minor group 12 (other managers and proprietors), the demand for these were apportioned according to the number working in them in 2014 who had a qualification of that level.

Altogether, two in five of roles arising in the engineering sector between 2014 and 2024 are projected to be at managerial and senior official (16%) or professional (24%) level, and a further 16% at associate professional level – all occupational groups are expected to require skills Level 3 and above (**Figure 10.4**).

Figure 10.4 Projected net requirement in the engineering sector for the period 2014 to 2024, by major occupational group – UK

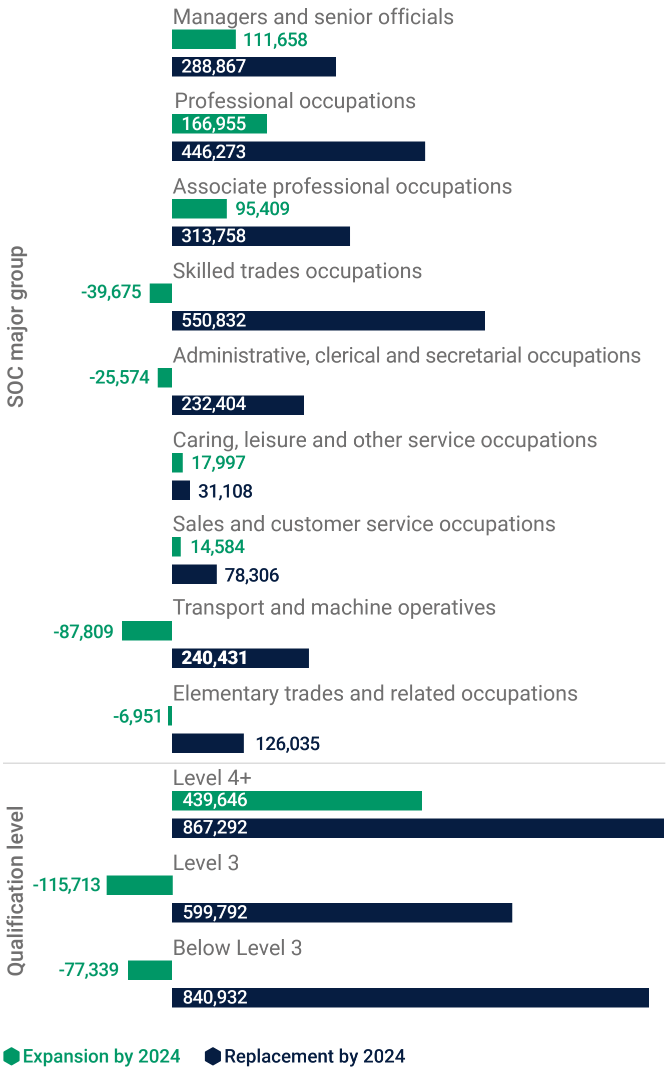


Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

Notably, the expansion demand for workers with Level 3 skills in the engineering sector is projected to be negative, with a decline of 115,713 jobs expected between 2014 and 2024. However, the replacement demand at this level is estimated at nearly 600,000 (**Figure 10.5** and **Figure 10.6**). Altogether, this equates to a net annual requirement of 48,408 workers with Level 3 skills in the engineering sector.

10.4 ONS. 'Standard occupational classification 2010: volume 1, structure and description of unit groups', 2010.

Figure 10.5 Projected expansion and replacement demand in the engineering sector for the period 2014 to 2024, by major occupational group and qualification level – UK



Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

This is consistent with predictions that the number of mid-level jobs will reduce in the coming years in favour of higher-skilled occupations. As **Figure 10.5** shows, in the engineering sector, there is expected to be sizeable negative expansion demand in skilled trades, administrative, clerical, and secretarial occupations, and transport and machine operatives, but significant numbers of new jobs in the top two major SOC groups.

Looking at the demand for Level 4 skills and above, expansion demand in the engineering sector is estimated to be 439,646 between 2014 and 2024, while the replacement demand is calculated as 867,292. This translates to a net annual requirement of 130,694 for those with skills Level 4 and above in the engineering sector. Again, this is a clear reflection of the progressive upskilling of the engineering sector.

Demand projections for the engineering sector by industry

29.8% of jobs projected to arise within the engineering sector between 2014 and 2014 are expected to be in construction (**Figure 10.7**). Manufacturing (24.7%), information and communication (18.9%) and professional, scientific, and technical activities (15.8%) also account for considerable proportions of the recruitment requirement expected in the engineering sector.

It is clear, however, that some industries in the engineering sector are constricting, while others are expanding. For example, the requirement for roles in manufacturing, while sizeable, is expected to be a result of replacement demand, as its projected expansion demand is negative. Engineering industries within wholesale, retail trade and repair of motor vehicles, transport and storage, and public administration and defence are likewise projected to experience negative expansion demand.

Meanwhile, there is expected to be strong positive expansion demand in engineering enterprises relating to electricity, gas, steam, and air conditioning supply and information and communication, where it accounts for 30.5% and 30.2%, respectively, of those industries' net requirements. Positive expansion demand is also expected to be significant in engineering enterprises in the construction industry (representing 28.6% of its net requirement).

Figure 10.6 Projected net requirement in the engineering sector for the period 2014 to 2024, by expansions/replacement demand, major occupational group and qualification level – UK

		Expansion demand by 2024	Replacement demand by 2024	Net requirement
SOC major group	1. Managers and senior officials	111,658	288,867	400,525
	2. Professional occupations	166,955	446,273	613,228
	3. Associate professional occupations	95,409	313,758	409,168
	4. Administrative, clerical and secretarial occupations	-25,574	232,404	206,831
	5. Skilled trades occupations	-39,675	550,832	511,157
	6. Caring, leisure and other service occupations	17,997	31,108	49,104
	7. Sales and customer service occupations	14,584	78,306	92,890
	8. Transport and machine operatives	-87,809	240,431	152,623
	9. Elementary trades and related occupations	-6,951	126,035	119,084
Qualification level	Level 4+	439,646	867,292	1,306,938
	Level 3	-115,713	599,792	484,079
	Below Level 3	-77,339	840,932	763,593

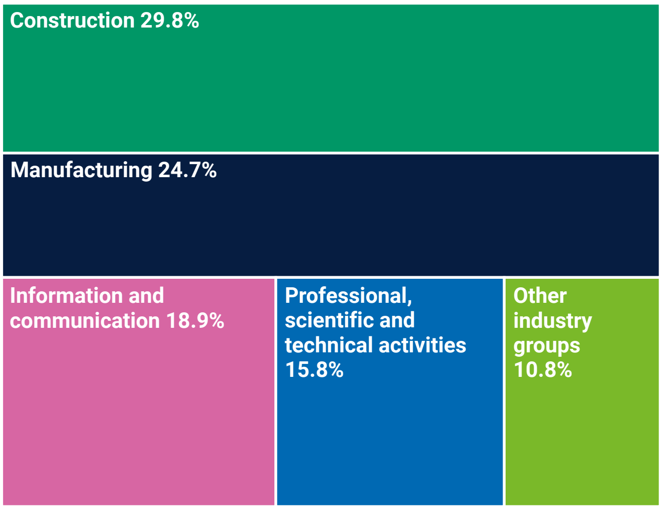
Source: IER, Working Futures 2014-2024 (EngineeringUK extension)

Figure 10.7 Projected net requirement in the engineering sector for the period 2014 to 2024, by major industry group – UK

	Expansion demand	Replacement demand	Total requirement	% of total requirement in engineering sector by 2024
Agriculture, forestry and fishing	0	0	0	0.0%
Administrative and support service activities	347	3,485	3,832	0.2%
Construction	217,319	542,721	760,039	29.8%
Electricity, gas, steam and air conditioning supply	18,277	41,707	59,984	2.3%
Information and communication	145,474	336,580	482,054	18.9%
Manufacturing	-239,855	870,537	630,682	24.7%
Mining and quarrying	4,181	25,119	29,300	1.1%
Professional, scientific and technical activities	96,257	306,303	402,560	15.8%
Public administration and defence; compulsory social security	-1,985	23,156	21,171	0.8%
Transportation and storage	-155	649	494	0.0%
Water supply sewerage, waste management and remediation	8,831	48,801	57,632	2.3%
Wholesale and retail trade; repair of motor vehicles	-4,818	90,521	85,702	3.4%
Other service activities	2,724	18,437	21,160	0.8%
All engineering industries	**246,595**	**2,308,015**	**2,554,610**	**100.0%**

Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

Figure 10.8 Projected net requirement in the engineering sector for the period 2014 to 2024, by selected industry group – UK



Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

1.2 million of the 2.5 million roles forecast to arise in the engineering sector – or 47.7% - are expected to be core or related engineering occupations.

Demand projections for the engineering sector by core and related engineering occupation

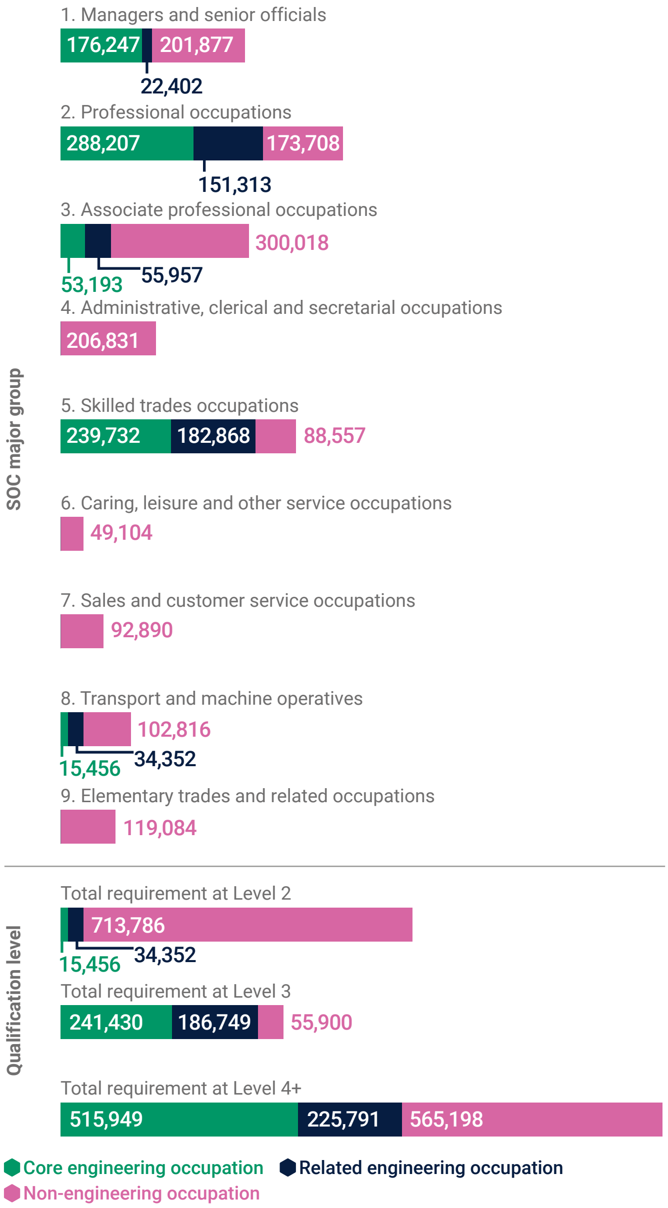
Discussion of demand projections in the previous section has considered the projected requirement expected to arise in the engineering sector broadly, and is not specific to occupations likely to require engineering skills.

More detailed analysis reveals that over 1.2 million of the 2.5 million roles forecast to arise in the engineering sector – or 47.7% - are expected to be core or related engineering occupations. This proportion is highest in skilled trades (82.7%) and professional occupations (71.7%), with just under half of managerial and senior official roles in the engineering sector also projected to be engineering occupations (49.6%) (**Figure 10.9**). In comparison, under a third of transport and machine operatives (32.6%) and 26.7% of associate professional occupations expected to arise between 2014 and 2024 are projected to be core or related engineering roles.

Once filtering for those occupations that require Level 3 qualifications and above, it is estimated that 1,170,000 graduate and technician engineering jobs will arise in the engineering sector between 2014 and 2024 – or 117,000 Level 3+ engineering roles in the engineering sector every year.

It is estimated that 1,170,000 graduate and technician engineering jobs will arise in the engineering sector between 2014 and 2024 – or 117,000 Level 3+ engineering roles in the engineering sector every year.

Figure 10.9 Projected net requirement in the engineering sector for the period 2014 to 2024, by major occupational group, qualification level, and core/related engineering classification (2014-2024) – UK



Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

10.3 – Demand projections for engineering occupations

It is of course possible that there is demand for engineering occupations outside of the engineering sector. In fact, at 86,000, the annual net requirement to fill graduate and technician engineering jobs in across the wider economy outside the engineering industry is considerable. That 42.3% of the projected requirement for Level 3+ engineering occupations is expected to arise outside of the engineering sector attests to the ubiquity of engineering skills required across industry (**Figure 10.10**).

Altogether, once factoring in both recruitment requirements within and outside of the engineering sector, 2,029,321 Level 3+ engineering occupations are projected to arise between 2014 and 2024. Assuming that this is uniformly distributed across the ten years, this means just under 203,000 engineering graduate and technicians will be required per year to meet expected demand across the economy, two thirds of whom will need Level 4+ skills (136,918) (**Figure 10.11**).

Attesting to the ubiquity of engineering skills required across industry, a further 86,000 Level 3+ jobs are expected to arise outside of the sector per year between 2014 and 2024.

This means that altogether, just under 203,000 engineering graduate and technicians will be required per year to meet expected demand across the economy, two thirds of whom will need Level 4+ skills.

Figure 10.10 Projected net requirement for engineering jobs for the period 2014 to 2024, by skills level and sector – UK

	Core	Related	All engineering occupations	% total demand	Non-engineering occupations	Total demand in sector
Engineering sector						
Level 3 demand in engineering sector	241,430	186,749	428,179	21.1%	55,900	484,079
Level 4+ demand in engineering sector	515,949	225,791	741,740	36.6%	565,198	1,306,938
Total Level 3+ demand in engineering sector	**757,379**	**412,540**	**1,169,919**	**57.7%**	**621,098**	**1,791,017**
Non-engineering sector						
Level 3 demand in non-engineering sector	125,859	106,100	231,959	11.4%	302,492	534,451
Level 4+ demand in non-engineering sector	354,657	272,786	627,443	30.9%	3,371,219	3,998,662
Total Level 3+ demand in non-engineering sector	**480,516**	**378,886**	**859,402**	**42.3%**	**3,673,710**	**4,533,112**
All sectors						
Total Level 3 demand	367,289	292,849	660,138	32.5%	358,392	1,018,530
Total Level 4+ demand	870,606	498,577	1,369,183	67.5%	3,936,417	5,305,600
Total Level 3+ demand	**1,237,895**	**791,426**	**2,029,321**	**100.0%**	**4,294,809**	**6,324,130**

Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

Figure 10.11 Projected net requirement for engineering jobs by occupational group, core/related engineering classification, and qualification level (2014-2024) – UK

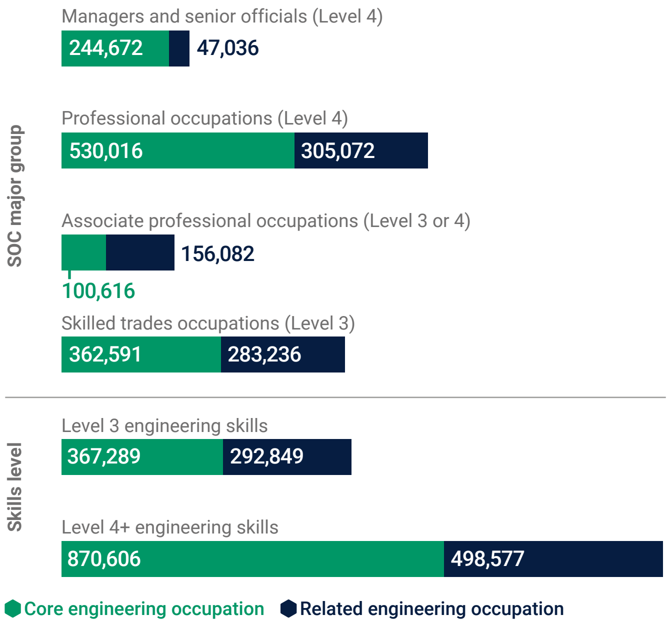
		Net engineering requirement			
	Engineering skills sub-group	Core occupations	Related occupations	Net requirement (2014-2024)	Annual requirement
Level 4	**1. Managers and senior officials**	**244,672**	**47,036**	**291,708**	**29,171**
	11. Corporate managers and directors	244,672	41,627	286,299	28,630
	12. Other managers and proprietors	0	5,409	5,409	541
	2. Professional occupations	**530,016**	**305,072**	**835,089**	**83,509**
	21. Science, research and engineering and technology professionals	462,791	169,518	632,309	63,231
	22. Health professionals	0	0	0	0
	23. Teaching and educational professionals	0	0	0	0
	24. Business, media and public service professionals	67,226	135,554	202,780	20,278
Level 3 or 4	**3. Associate professional occupations**	**100,616**	**156,082**	**256,697**	**25,670**
	12. Other managers and proprietors	0	5,409	5,409	541
	12a. Level 4 qualifications or above	0	4,336	4,336	434
	12b. Level 3 qualifications or below	0	1,073	1,073	107
	31. Science, engineering and technology associate professionals	82,663	92,552	175,215	17,521
	31a. Level 4 qualifications or above	79,690	88,807	168,497	16,850
	31b. Level 3 qualifications or below	2,972	3,745	6,717	672
	32. Health and social care associate professionals	0	0	0	0
	32a. Level 4 qualifications or above	0	0	0	0
	32b. Level 3 qualifications or below	0	0	0	0
	33. Protective service occupations	0	0	0	0
	33a. Level 4 qualifications or above	0	0	0	0
	33b. Level 3 qualifications or below	0	0	0	0
	34. Culture, media, and sports occupations	0	48,060	48,060	4,806
	34a. Level 4 qualifications or above	0	44,830	44,830	4,483
	34b. Level 3 qualifications or below	0	3,230	3,230	323
	35. Business and public service associate professionals	17,953	15,470	33,423	3,342
	35a. Level 4 qualifications or above	16,227	13,905	30,132	3,013
	35b. Level 3 qualifications or below	1,725	1,566	3,291	329
Level 3	**5. Skilled trades occupations**	**362,591**	**283,236**	**645,827**	**64,583**
	51. Skilled agricultural and related trades	0	0	0	0
	52. Skilled metal, electrical and electronic trades	252,356	2,581	254,937	25,494
	53. Skilled construction and building trades	110,235	280,655	390,890	39,089
	54. Textiles, printing and other skilled trades	0	0	0	0
Level 2	**4. Administrative, clerical and secretarial occupations**	**0**	**0**	**0**	**0**
	41. Administrative occupations	0	0	0	0
	42. Secretarial and related occupations	0	0	0	0
	6. Caring, leisure and other service occupations	**0**	**0**	**0**	**0**
	61. Caring personal service occupations	0	0	0	0
	62. Leisure, travel and related personal service occupations	0	0	0	0
	7. Sales and customer service occupations	**0**	**0**	**0**	**0**
	71. Sales occupations	0	0	0	0
	72. Customer service occupations	0	0	0	0
	8. Transport and machine operatives	**29,603**	**81,859**	**111,462**	**11,146**
	81. Process, plant and machine operatives	29,603	70,574	100,177	10,018
	82. Transport and mobile machine drivers and operatives	0	11,285	11,285	1,129
Level 1	**Elementary trades and related occupations**	**0**	**0**	**0**	**0**
	91. Elementary trades and related occupations	0	0	0	0
	92. Elementary administration and service occupations	0	0	0	0
Total demand		**1,267,498**	**873,284**	**2,140,783**	**214,078**
Total demand for Level 3+ skills		**1,237,895**	**791,426**	**2,029,321**	**202,932**
	Level 4+ (sub groups: 11, 12a, 21, 24, 31a, 34a, 35a)	**870,606**	**498,577**	**1,369,183**	**136,918**
	Level 3 (sub groups: 12b, 31b, 34b, 35b, 52, 53)	**367,289**	**292,849**	**660,138**	**66,014**

Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

While the majority of demand for engineering roles are expected to 'core' in nature – that is, roles that require the consistent application of engineering knowledge and skills to execute the role effectively – it is notable that 39.0% will require a mixed application of engineering knowledge and skill alongside other skill sets ('related' engineering occupations). This proportion increases for associate professional occupations, where 60.8% of projected demand is expected to be for 'related' engineering roles (**Figure 10.12**).

The implications of this are two-fold. First, it underscores the importance of those coming out of the educational pipeline developing a well-rounded set of skills, as has been discussed in **Chapter 8**. Second, it suggests we should foster engineering skills not just among those are likely to enter into engineering courses, but also among young people more broadly. Graduates who have not studied engineering can and often do progress into engineering-related roles, a consideration accounted for in the supply calculations elaborated later in this chapter.

Figure 10.12 Projected net requirement for Level 3+ engineering jobs for the period 2014 to 2024, by major occupational group, qualification level, and core/related engineering classification – UK

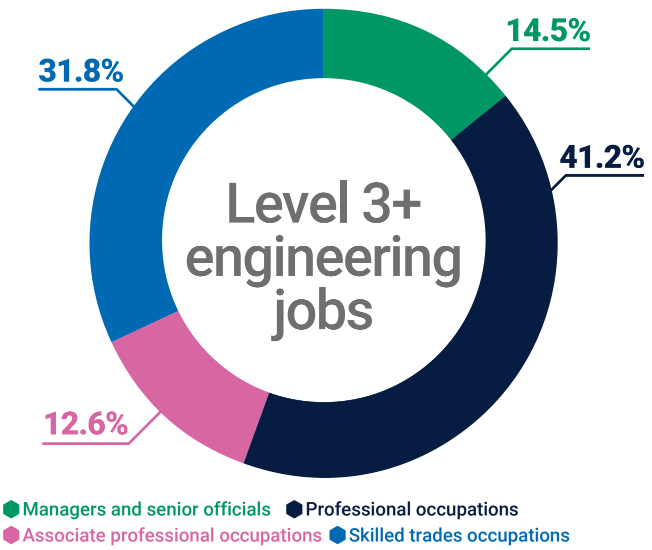


Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

39.0% of engineering demand is for roles that will require a mixed application of engineering knowledge and skill alongside other skill sets ('related' engineering occupations).

Likewise, that the majority of Level 3+ engineering roles are projected to arise in professional occupations (41.2%) or in the skilled trades (31.8%) clearly articulates the need for the engineering sector to actively cultivate the talent pipeline through both technical and academic routes into engineering (**Figure 10.13**).

Figure 10.13 Projected net requirement for Level 3+ engineering jobs for the period 2014 to 2024, by major occupational group – UK



Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

10.4 – Demand projections by region and nation

Figure 10.14 uses these projections to paint a picture of net engineering requirements in the UK nations and regions. It is expected that between 2014 and 2024, 87.3% of Level 3+ engineering occupations arising across UK industry will be in England. These vacancies are projected to appear mostly in London (accounting for 18.0% of demand for Level 3+ engineering roles) and the South East (16.3%). The lowest net engineering requirements at Level 3+ are projected to be in Northern Ireland (2.2%), the North East of England (3.0%), and Wales (3.4%).

Figure 10.14 Projected net requirement for Level 3+ engineering jobs for the period 2014 to 2024, by nation/region

	Demand for Level 3+ engineering occupations		Total Level 3+ requirement (all jobs)	Engineering demand as % of Level 3+ requirement	Total requirement (all levels, and jobs)	Engineering demand as % of total requirement	Regional demand as % of UK engineering demand
	Core occupations	Related occupations					
England	1,065,865	706,571	5,571,848	31.8%	12,798,859	13.8%	87.3%
North East	36,732	24,301	175,061	34.9%	511,935	11.9%	3.0%
North West	121,450	77,151	584,190	34.0%	1,578,622	12.6%	9.8%
Yorkshire and the Humber	89,450	52,006	415,118	34.1%	1,095,237	12.9%	7.0%
East Midlands	92,859	44,386	387,905	35.4%	984,239	13.9%	6.8%
West Midlands	111,065	62,731	486,658	35.7%	1,239,157	14.0%	8.6%
East	107,419	77,918	586,057	31.6%	6,298,597	2.9%	9.1%
London	193,763	171,536	1,409,358	25.9%	2,571,373	14.2%	18.0%
South East	202,070	128,478	989,575	33.4%	2,125,616	15.6%	16.3%
South West	108,944	69,649	537,927	33.2%	965,466	18.5%	8.8%
Wales	45,948	23,208	202,315	34.2%	606,977	11.4%	3.4%
Scotland	95,902	46,761	426,368	33.5%	1,178,376	12.1%	7.0%
Northern Ireland	28,811	15,843	123,598	36.1%	351,396	12.7%	2.2%
UK	**1,237,895**	**791,426**	**6,324,129**	**32.1%**	**14,935,607**	**13.6%**	**100.0%**

Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

10.5 – Supply analysis

Our demand estimates do not consider movements across the labour market ie. workers transferring from other industry sectors into engineering sectors and vice versa. Put another way, they assume that these flows compensate each other, and therefore do not materially impact the engineering skills shortfall.

This is a key assumption of the *Working Futures* models, and one that has been tested and confirmed to hold by independent studies – including one commissioned by EngineeringUK to assess whether this held true specifically in relation to the engineering sector. Using Labour Force Survey (LFS) data for the period 2006 to 2016, research undertaken by the Institute of Employment Studies on EngineeringUK's behalf concluded that annual flows into and out of the engineering workforce over the last decade were indeed broadly net neutral. Further details about this research can be found at the end of this chapter.

This has two implications. First, the engineering skills shortfall estimates presented here are robust against the omission of net intersectoral mobility. Second, while there is potential to reduce the shortfall by attracting more workers from other sectors and improving retention, so far annual net inflows into the engineering sector have been too small to make a tangible difference.

Thus, in our supply analysis, we focus on estimating the number of people achieving Level 3+ qualifications through the educational pipeline. Specifically, we consider the supply of engineering skills to come wholly from higher education graduates and apprenticeship achievements. We recognise that there are some limitations to this approach; for example, it is possible some people may gain Level 3+ engineering-related qualifications through further education (FE). Owing to a lack of FE data at the granularity required, we are necessarily limited in our approach.

The following analysis in this section provides a detailed description of how we calculate our supply.

Level 3 supply calculations

The annual supply of people with Level 3 engineering skills who are available to work in engineering occupations is taken to be the number of people who complete a Level 3 engineering-related apprenticeship in the UK. On this basis, the most recent annual supply figure stands at 33,483 (**Figure 10.15**).

To aid analysis of our shortfall calculations, we undertook a mapping exercise of engineering-related apprenticeship frameworks against SOC descriptors to categorise apprenticeships into the core or related engineering occupations they would likely lead to. This exercise factored in count at each level, the number of SOC codes within core/

related engineering occupations, and the level of consistency that could be achieved across different national frameworks, given the level of detail available. Where possible, further information concerning the framework was reviewed to assess what types of occupations an associated apprenticeship could lead to.

Figure 10.15 Number of engineering-related apprenticeship achievements in the academic year 2015 to 2016, by nation and core/related engineering classification

	England	Scotland	Wales	Northern Ireland	UK total
Level 3					
Core engineering	17,780	2,411	845	1,238	22,274
Related engineering	8,020	1,893	890	406	11,209
Total Level 3 supply	**25,800**	**4,304**	**1,735**	**1,644**	**33,483**
Level 4+					
Core engineering	170	0	25		195
Related engineering	530	436	10		976
Total Level 4+ supply	**700**	**436**	**35**	**0**	**1,171**
Total (Level 3+)					
Core engineering	17,950	2,411	870	1,238	22,469
Related engineering	8,550	2,329	900	406	12,185
Total Level 3+ supply	**26,500**	**4,740**	**1,770**	**1,644**	**34,654**

Source: Data collated in Chapter 6 from Skills Funding Agency, Skills Development Scotland, Welsh Government, Department for Education and Learning Northern Ireland.

Because no information on achievements in engineering-related frameworks is available for Northern Ireland, these figures include all participants in these types of apprenticeships in 2016, resulting in a small overestimation of the Level 3 supply.

Level 4+ supply calculations

At Level 4+, our supply calculations are more nuanced, with both an ‘estimated’ and a ‘potential’ supply calculated. In both calculations, we furthermore take into account the number of people who complete a Level 4 and above engineering-related apprenticeship (**Figure 10.16**).

Revisions to Level 4+ supply calculations

In previous reports, supply was calculated in two ways:

- **Historic supply**, defined as the “number of UK graduates who were employed in engineering roles equivalent to Level 4”
- **Potential supply**, defined as “everyone who could have entered the workforce with these Level 4+ engineering-related skills”

The historic supply previously was restricted to *UK-domiciled* engineering graduates employed in Level 4+ engineering roles. This was used as a proxy for location of employment. Under the revised method, the ‘historic’ supply has been replaced with an ‘estimated supply,’ which includes all graduates, irrespective of domicile, but restricted to those who are employed in a Level 4+ engineering role in the UK.

The **‘potential’ supply** remains an indication of those eligible to be/employed in engineering more broadly, using the previous subject tiering system to account for those less likely to be eligible to work in an engineering occupation/the sector. It is similarly unrestricted by location of unemployment.

To both the ‘estimated’ and ‘potential’ supply, **domicile-specific employment rates** have been applied to their respective sub-groups. Previously, the same employment rates (irrespective of domicile) were applied to UK, EU, and non-EU graduates. This did not take into account the possibility that this differs by domicile. Where no rate was available, as in the case of non-EU students, EU rates have been applied.

A comparison of our previous and current method of calculating the supply of Level 4+ skills is outlined in **Figure 10.16**.

Our demand projections assume labour movement is net neutral. This is a key assumption underpinning *Working Future* and has been confirmed to hold by independent studies.

Figure 10.16 Summary of changes to Level 4+ skills supply calculations

	Original method		Revised method	
	Historic	**Potential**	**Estimated**	**Potential**
Tier 1 Engineering and technology	UK domiciled qualifiers employed in a Level 4+ engineering role	All domiciled qualifiers in employment (*Overall employment rate applied*)	All domiciled qualifiers employed in a Level 4+ engineering role in the UK (*Domicile specific employment rates applied*)	All domiciled qualifiers in employment (*Domicile specific employment rates applied*)
Tier 2 Architecture, building and planning Computer science Mathematical sciences Physical sciences	UK domiciled qualifiers employed in a Level 4+ engineering role	All domiciled qualifiers in engineering employment (*Overall employment rate applied*)	All domiciled qualifiers employed in a Level 4+ engineering role in the UK (*Domicile specific employment rates applied*)	All domiciled qualifiers in engineering employment (*Domicile specific employment rates applied*)
Tier 3 Agriculture and related subjects Biological sciences Business and administrative studies Combined Creative arts and design Education Historical and philosophical studies Languages Law Mass communications and documentation Medicine and dentistry Social studies Subjects allied to medicine Veterinary sciences	UK domiciled qualifiers employed in a Level 4+ engineering role	All domiciled qualifiers in Level 4+ engineering employment (*Overall employment rate applied*)	All domiciled qualifiers employed in a Level 4+ engineering role in the UK (*Domicile specific employment rates applied*)	All domiciled qualifiers in Level 4+ engineering employment (*Domicile specific employment rates applied*)

The **estimated supply** is an approximation of graduates who were employed in Level 4+ engineering roles in the UK six months after graduating. Rates in which graduates of different degree levels and domiciles are 1) employed (either in full-time work, part-time work, or work and further study) 2) employed within the UK, and 3) employed in Level 4+ engineering occupations are first calculated based on analysis of Destinations of Leavers in Higher Education (DLHE) data. These are then multiplied by the number of qualifiers within the respective degree level and domicile.

For example, some 18,384 UK domiciled students graduated with an engineering and technology first degree in the academic year 2015 to 2016. This figure is first multiplied by 74.8%, the rate in which DLHE qualifiers within this domicile, subject area, and degree level entered employment (be it full-time work, part-time work, or work and further study). It is further multiplied by the rate in which UK domiciled engineering and technology first degree graduates who were employed entered employment within the UK (96.9%), and finally by the rate in which they entered Level 4+ engineering occupations (64.6%). From these calculations, we estimate that 8,603 UK domiciled engineering and technology first degree qualifiers were employed in a Level 4+ engineering occupation in the UK within six months of graduating.

This process is repeated for each and every combination of domicile, degree level, and subject area to arrive at a total estimate of qualifiers working in engineering roles requiring Level 4+ skills in the UK six months after graduating in 2015/16. For international qualifiers outside of the EU, who do not participate in the DLHE, employment rates from EU domiciled qualifiers are applied.

On this basis, an estimated supply of graduates with Level 4+ engineering-related skills for the latest academic year in which data is available is calculated. This is presented by domicile, degree level and subject area in Figure 10.17.

The estimated supply is an approximation of graduates who were employed in Level 4+ engineering roles in the UK six months after graduating. Across subjects and degree levels, we estimate this to be 58,670.

The potential supply, in contrast, is an indication of those eligible to be/employed in engineering more broadly. As noted in **Chapter 8**, many graduates with degrees in subjects other than engineering and technology enter employment in engineering-related roles. To account for this, three subject tiers of graduate supply are used. The subjects have been tiered according to the number of graduates who have traditionally entered the engineering workforce. As those from tiers 2 and 3 are less likely to work in an engineering-related occupation, more stringent criteria are applied to these groups when calculating their contribution to the potential supply.

Supply calculations: subject tiers

Tier 1 contains engineering and technology graduates at different levels of HE study, who are expected to have high rates of transition into engineering occupations.

Tier 2 contains graduates from key STEM subject groups known to have a high progression rate into engineering occupations. These are: architecture, building & planning; computer science; mathematical science; and physical sciences.

Tier 3 contains graduates from all other subject areas, ranging from creative arts and design to biological sciences. Although the rate transitioning into engineering occupations may be small, the total number of graduates to which it is applied is large, so the number entering engineering roles is significant.

For tier 1, the potential supply is the number of engineering and technology qualifiers multiplied simply by the domicile-specific rate in which DLHE qualifiers within the respective degree level entered employment. This assumes all those with an engineering and technology degree are potentially employable in an engineering-related role at graduate level.

For tier 2, the criteria to be considered a part of the potential supply are stricter. The number of qualifiers within these key STEM subject areas is first multiplied by the domicile-specific rate in which DLHE qualifiers within the respective degree level were employed, and then further multiplied by the rate *working in an engineering* role.

The strictest criteria are adopted for tier 3. The number of qualifiers within these subject areas is multiplied by the domicile-specific rate in which DLHE qualifiers within the respective degree level were employed, then further multiplied by the rate *working in an engineering role requiring Level 4+ skills*. This is an attempt to account for the fact that relatively few graduates from tier 3 have the skills required for engineering occupations at graduate level.

For the same reason, only graduates who studied Tier 1 and Tier 2 subjects are considered to form the supply for 'core' engineering occupations, which by definition are engineering-based roles that require the consistent application of engineering knowledge and skills to execute the role effectively.

Using this methodology, a 'potential' supply of graduates with Level 4+ engineering-related skills from the academic year 2015 to 2016 is calculated. This is presented by domicile, degree level and subject area in **Figure 10.18**.

Only graduates who studied Tier 1 and Tier 2 subjects are considered to form the supply for 'core' engineering occupations, which by definition are engineering-based roles that require the consistent application of engineering knowledge and skills to execute the role effectively.

Figure 10.17 Estimated supply of graduates with Level 4+ engineering-related skills from the academic year 2015 to 2016 – UK

		UK domiciled		EU domiciled		Non EU domiciled		
		No. qualifiers	Estimated no. employed	No. qualifiers	Estimated no. employed	No. qualifiers	Estimated no. employed	Total estimated supply
Tier 1 (estimated no. employed in UK Level 4+ engineering occupations)								
Engineering & technology	First degree	18,385	8,605	1,910	460	6,525	1,580	10,640
	Other undergraduate	3,745	1,650	55	-	445	15	1,665
	Taught postgraduate	4,020	1,905	2,295	525	9,155	2,085	4,510
	Research postgraduate	1,430	520	515	125	1,615	385	1,030
Total Tier 1	**Tier 1 total**	**27,580**	**12,675**	**4,780**	**1,110**	**17,740**	**4,065**	**17,855**
Tier 2 (estimated no. employed in UK Level 4+ engineering occupations)								
Architecture, building & planning	First degree	6,405	4,030	600	215	1,345	480	4,725
	Other undergraduate	1,340	655	65	30	135	55	740
	Taught postgraduate	4,040	2,585	575	220	2,810	1,065	3,870
	Research postgraduate	190	35	55	5	205	15	55
	All degree levels	**11,975**	**7,310**	**1,300**	**465**	**4,490**	**1,615**	**9,395**
Computer science	First degree	14,420	6,960	1,210	450	1,530	570	7,975
	Other undergraduate	1,355	280	20	-	15	-	285
	Taught postgraduate	2,465	1,250	740	225	3,500	1,060	2,535
	Research postgraduate	495	165	210	25	460	55	250
	All degree levels	**18,730**	**8,660**	**2,180**	**700**	**5,505**	**1,685**	**11,040**
Mathematical sciences	First degree	7,190	650	370	5	1,415	20	675
	Other undergraduate	210	10	10	-	15	-	10
	Taught postgraduate	685	70	360	10	1,255	35	110
	Research postgraduate	355	30	140	5	210	10	40
	All degree levels	**8,440**	**760**	**880**	**20**	**2,895**	**60**	**840**
Physical sciences	First degree	16,195	1,685	690	30	1,115	45	1,760
	Other undergraduate	660	50	45	-	30	-	50
	Taught postgraduate	2,600	510	575	50	1,920	160	720
	Research postgraduate	2,100	295	485	30	800	55	380
	All degree levels	**21,560**	**2,540**	**1,800**	**110**	**3,865**	**260**	**2,910**
Total Tier 2	First degree	44,210	13,325	2,875	695	5,405	1,115	15,140
	Other undergraduate	3,560	1,000	145	30	190	55	1,085
	Taught postgraduate	9,790	4,420	2,250	500	9,485	2,320	7,235
	Research postgraduate	3,145	525	890	70	1,675	135	725
	Tier 2 total	**60,710**	**19,265**	**6,160**	**1,295**	**16,760**	**3,625**	**24,185**
Tier 3 (estimated no. employed in UK Level 4+ engineering occupations)								
Agriculture & related subjects	First degree	2,705	235	80	5	190	15	260
	Other undergraduate	1,275	45	25	-	30	-	50
	Taught postgraduate	720	105	145	20	470	60	180
	Research postgraduate	115	10	35	-	105	-	10
	All degree levels	**4,820**	**395**	**285**	**25**	**800**	**75**	**495**
Biological sciences	First degree	41,145	855	1,940	10	1,890	10	875
	Other undergraduate	2,310	20	55	-	45	-	20
	Taught postgraduate	8,385	220	1,100	10	2,215	20	250
	Research postgraduate	2,580	90	480	15	740	20	120
	All degree levels	**54,420**	**1,185**	**3,570**	**35**	**4,895**	**50**	**1,270**
Business & administrative studies	First degree	40,420	1,730	4,635	120	18,320	470	2,315
	Other undergraduate	4,865	245	185	5	850	20	270
	Taught postgraduate	16,240	1,545	5,355	140	36,200	930	2,615
	Research postgraduate	495	20	150	-	645	-	20
	All degree levels	**62,020**	**3,545**	**10,320**	**260**	**56,015**	**1,415**	**5,220**
Combined	First degree	3,610	255	30	-	85	-	255
	Other undergraduate	845	45	115	-	115	-	45
	Taught postgraduate	150	10	5	-	-	-	10
	Research postgraduate	5	-	-	-	-	-	-
	All degree levels	**4,605**	**315**	**150**	**-**	**205**	**-**	**315**

Figure 10.17 continued

		UK domiciled		EU domiciled		Non EU domiciled		
		No. qualifiers	Estimated no. employed	No. qualifiers	Estimated no. employed	No. qualifiers	Estimated no. employed	Total estimated supply
Creative arts & design	First degree	36,750	3,355	2,220	180	3,115	255	3,790
	Other undergraduate	2,210	70	85	-	410	5	80
	Taught postgraduate	5,200	365	1,370	110	4,525	360	835
	Research postgraduate	560	25	135	-	175	5	30
	All degree levels	**44,720**	**3,820**	**3,810**	**295**	**8,225**	**625**	**4,735**
Education	First degree	18,370	80	115	-	135	-	80
	Other undergraduate	8,360	40	60	-	130	-	40
	Taught postgraduate	36,855	175	1,120	5	2,845	10	185
	Research postgraduate	775	10	105	-	330	-	10
	All degree levels	**64,360**	**300**	**1,400**	**5**	**3,440**	**10**	**315**
Historical & philosophical studies	First degree	17,025	320	525	5	615	10	335
	Other undergraduate	685	25	10	-	30	-	25
	Taught postgraduate	3,380	70	480	5	1,325	10	85
	Research postgraduate	1,160	15	265	5	515	5	25
	All degree levels	**22,250**	**435**	**1,280**	**15**	**2,490**	**25**	**470**
Languages	First degree	20,235	300	1,025	5	1,095	10	315
	Other undergraduate	855	10	105	-	1,665	25	35
	Taught postgraduate	2,975	50	875	10	2,405	20	80
	Research postgraduate	900	20	205	-	495	-	20
	All degree levels	**24,965**	**375**	**2,215**	**15**	**5,660**	**55**	**445**
Law	First degree	13,750	180	1,070	5	3,830	20	210
	Other undergraduate	870	55	45	5	90	5	65
	Taught postgraduate	5,370	350	1,575	20	4,390	55	425
	Research postgraduate	220	-	85	-	220	5	10
	All degree levels	**20,205**	**590**	**2,775**	**30**	**8,525**	**85**	**705**
Mass communications & documentation	First degree	9,665	270	815	15	1,160	20	305
	Other undergraduate	220	5	5	-	10	-	5
	Taught postgraduate	2,310	85	660	15	3,080	75	175
	Research postgraduate	120	10	45	-	90	-	10
	All degree levels	**12,320**	**365**	**1,525**	**30**	**4,340**	**95**	**490**
Medicine & dentistry	First degree	8,930	5	215	-	895	-	5
	Other undergraduate	160	-	-	-	10	-	-
	Taught postgraduate	3,870	70	470	-	1,505	-	70
	Research postgraduate	1,690	40	270	5	485	5	55
	All degree levels	**14,650**	**110**	**955**	**5**	**2,895**	**5**	**125**
Social studies	First degree	36,155	740	2,360	25		45	815
	Other undergraduate	4,825	30	35	-	170	-	30
	Taught postgraduate	10,280	235	2,490	50	8,860	175	460
	Research postgraduate	1,115	15	410	10	840	15	35
	All degree levels	**52,375**	**1,020**	**5,305**	**85**	**13,875**	**235**	**1,340**
Subjects allied to medicine	First degree	42,805	315	1,405	5	2,120	10	330
	Other undergraduate	13,355	65	105	-	115	-	65
	Taught postgraduate	15,655	215	885	15	2,495	40	270
	Research postgraduate	1,175	25	230	5	475	15	45
	All degree levels	**72,990**	**615**	**2,625**	**25**	**5,205**	**65**	**705**
Veterinary science	First degree	875	5	20	-	175	-	5
	Other undergraduate	20	-	-	-	-	-	-
	Taught postgraduate	155	-	25	-	10	-	-
	Research postgraduate	55	-	5	-	25	-	-
	All degree levels	**1,110**	**5**	**50**	**-**	**210**	**-**	**5**
Total Tier 3	First degree	292,435	8,640	16,455	385	37,630	860	9,880
	Other undergraduate	40,850	660	830	10	3,675	55	725
	Taught postgraduate	111,550	3,495	16,555	390	70,330	1,750	5,635
	Research postgraduate	10,970	280	2,425	40	5,140	75	395
	Tier 3 total	**455,810**	**13,070**	**36,265**	**820**	**116,775**	**2,740**	**16,630**
Total estimated supply across subjects and degree levels		**544,100**	**45,015**	**47,200**	**3,230**	**151,275**	**10,430**	**58,670**

Source: HESA, student record 2015/16 and Destination of Leavers from Higher Education Survey 2015/16
All data has been weighted by full-person equivalent (FPE) and counts rounded to the nearest 5 in accordance with HESA policy. Counts may therefore not sum to totals provided.

Figure 10.18 Potential supply of graduates with Level 4+ engineering-related skills from the academic year 2015 to 2016 – UK

		UK domiciled		EU domiciled		Non EU domiciled		
		No. qualifiers	Potential no. employed	No. qualifiers	Potential no. employed	No. qualifiers	Potential no. employed	Total potential supply
Tier 1 (estimated no. employed within/outside UK)								
Engineering & technology	First degree	18,385	13,755	1,910	1,080	6,525	3,695	18,525
	Other undergraduate	3,745	2,740	55	15	445	135	2,890
	Taught postgraduate	4,020	3,285	2,295	1,690	9,155	6,740	11,710
	Research postgraduate	1,430	1,235	515	440	1,615	1,380	3,055
Total Tier 1	**Tier 1 total**	**27,580**	**21,015**	**4,780**	**3,230**	**17,740**	**11,940**	**36,185**
Tier 2 (estimated no. employed in engineering occupations within/outside UK)								
Architecture, building & planning	First degree	6,405	4,180	600	325	1,345	725	5,230
	Other undergraduate	1,340	730	65	45	135	90	870
	Taught postgraduate	4,040	2,650	575	315	2,810	1,555	4,520
	Research postgraduate	190	40	55	10	205	30	80
	All degree levels	**11,975**	**7,600**	**1,300**	**695**	**4,490**	**2,400**	**10,695**
Computer science	First degree	14,420	7,210	1,210	620	1,530	785	8,615
	Other undergraduate	1,355	295	20	5	15	5	305
	Taught postgraduate	2,465	1,315	740	450	3,500	2,120	3,885
	Research postgraduate	495	165	210	55	460	115	340
	All degree levels	**18,730**	**8,990**	**2,180**	**1,125**	**5,505**	**3,025**	**13,145**
Mathematical sciences	First degree	7,190	685	370	15	1,415	65	765
	Other undergraduate	210	15	10	-	15	5	20
	Taught postgraduate	685	70	360	25	1,255	80	175
	Research postgraduate	355	30	140	10	210	15	50
	All degree levels	**8,440**	**800**	**880**	**50**	**2,895**	**165**	**1,015**
Physical sciences	First degree	16,195	1,785	690	40	1,115	70	1,895
	Other undergraduate	660	65	45	5	30	5	75
	Taught postgraduate	2,600	535	575	95	1,920	315	950
	Research postgraduate	2,100	305	485	50	800	80	435
	All degree levels	**21,560**	**2,695**	**1,800**	**190**	**3,865**	**470**	**3,350**
Total Tier 2	First degree	44,210	13,855	2,875	1,005	5,405	1,645	16,505
	Other undergraduate	3,560	1,110	145	55	190	100	1,265
	Taught postgraduate	9,790	4,570	2,250	885	9,485	4,075	9,530
	Research postgraduate	3,145	545	890	120	1,675	240	905
	Tier 2 total	**60,710**	**20,080**	**6,160**	**2,065**	**16,760**	**6,060**	**28,200**
Tier 3 (estimated no. employed in Level 4+ engineering occupations within/outside UK)								
Agriculture & related subjects	First degree	2,705	245	80	5	190	15	265
	Other undergraduate	1,275	45	25	-	30	-	50
	Taught postgraduate	720	110	145	30	470	95	235
	Research postgraduate	115	10	35	5	105	10	20
	All degree levels	**4,820**	**410**	**285**	**40**	**800**	**120**	**570**
Biological sciences	First degree	41,145	875	1,940	30	1,890	30	935
	Other undergraduate	2,310	20	55	-	45	-	20
	Taught postgraduate	8,385	225	1,100	25	2,215	45	295
	Research postgraduate	2,580	95	480	25	740	40	160
	All degree levels	**54,420**	**1,220**	**3,570**	**80**	**4,895**	**115**	**1,410**
Business & administrative studies	First degree	40,420	1,770	4,635	180	18,320	705	2,655
	Other undergraduate	4,865	255	185	5	850	20	275
	Taught postgraduate	16,240	1,625	5,355	345	36,200	2,320	4,285
	Research postgraduate	495	25	150	-	645	10	35
	All degree levels	**62,020**	**3,670**	**10,320**	**530**	**56,015**	**3,055**	**7,250**
Combined	First degree	3,610	270	30	-	85	-	270
	Other undergraduate	845	45	115	-	115	-	50
	Taught postgraduate	150	10	5	-	-	-	10
	Research postgraduate	5	-	-	-	-	-	-
	All degree levels	**4,605**	**330**	**150**	**-**	**205**	**-**	**330**

Figure 10.18 continued

		UK domiciled		EU domiciled		Non EU domiciled		
		No. qualifiers	Potential no. employed	No. qualifiers	Potential no. employed	No. qualifiers	Potential no. employed	Total potential supply
Creative arts & design	First degree	36,750	3,495	2,220	275	3,115	385	4,155
	Other undergraduate	2,210	75	85	-	410	10	85
	Taught postgraduate	5,200	390	1,370	175	4,525	570	1,130
	Research postgraduate	560	25	135	10	175	10	45
	All degree levels	**44,720**	**3,980**	**3,810**	**460**	**8,225**	**975**	**5,415**
Education	First degree	18,370	80	115	-	135	-	80
	Other undergraduate	8,360	40	60	-	130	-	40
	Taught postgraduate	36,855	180	1,120	5	2,845	15	200
	Research postgraduate	775	10	105	-	330	5	20
	All degree levels	**64,360**	**310**	**1,400**	**10**	**3,440**	**20**	**340**
Historical & philosophical studies	First degree	17,025	325	525	10	615	15	350
	Other undergraduate	685	25	10	-	30	-	25
	Taught postgraduate	3,380	75	480	10	1,325	20	105
	Research postgraduate	1,160	15	265	10	515	20	45
	All degree levels	**22,250**	**445**	**1,280**	**30**	**2,490**	**50**	**525**
Languages	First degree	20,235	320	1,025	15	1,095	15	350
	Other undergraduate	855	10	105	-	1,665	25	35
	Taught postgraduate	2,975	55	875	25	2,405	65	145
	Research postgraduate	900	20	205	-	495	5	25
	All degree levels	**24,965**	**410**	**2,215**	**40**	**5,660**	**110**	**560**
Law	First degree	13,750	185	1,070	15	3,830	55	260
	Other undergraduate	870	55	45	5	90	10	70
	Taught postgraduate	5,370	365	1,575	40	4,390	115	520
	Research postgraduate	220	-	85	-	220	5	10
	All degree levels	**20,205**	**610**	**2,775**	**65**	**8,525**	**190**	**865**
Mass communications & documentation	First degree	9,665	275	815	25	1,160	40	345
	Other undergraduate	220	5	5	-	10	-	5
	Taught postgraduate	2,310	90	660	25	3,080	110	220
	Research postgraduate	120	10	45	-	90	-	10
	All degree levels	**12,320**	**380**	**1,525**	**50**	**4,340**	**145**	**575**
Medicine & dentistry	First degree	8,930	5	215	-	895	-	5
	Other undergraduate	160	-	-	-	10	-	-
	Taught postgraduate	3,870	70	470	10	1,505	25	105
	Research postgraduate	1,690	40	270	10	485	15	65
	All degree levels	**14,650**	**115**	**955**	**15**	**2,895**	**40**	**170**
Social studies	First degree	36,155	755	2,360	50	4,005	85	885
	Other undergraduate	4,825	30	35	-	170	-	30
	Taught postgraduate	10,280	250	2,490	100	8,860	360	710
	Research postgraduate	1,115	20	410	10	840	20	50
	All degree levels	**52,375**	**1,060**	**5,305**	**160**	**13,875**	**460**	**1,680**
Subjects allied to medicine	First degree	42,805	325	1,405	10	2,120	15	345
	Other undergraduate	13,355	65	105	-	115	-	70
	Taught postgraduate	15,655	220	885	35	2,495	95	350
	Research postgraduate	1,175	25	230	15	475	30	70
	All degree levels	**72,990**	**635**	**2,625**	**60**	**5,205**	**140**	**840**
Veterinary science	First degree	875	5	20	-	175	-	5
	Other undergraduate	20	-	-	-	-	-	-
	Taught postgraduate	155	-	25	-	10	-	-
	Research postgraduate	55	-	5	-	25	-	-
	All degree levels	**1,110**	**5**	**50**	**-**	**210**	**-**	**5**
Total Tier 3	First degree	292,435	8,930	16,455	615	37,630	1,355	10,905
	Other undergraduate	40,850	675	830	20	3,675	70	760
	Taught postgraduate	111,550	3,665	16,555	815	70,330	3,835	8,310
	Research postgraduate	10,970	305	2,425	85	5,140	165	560
	Tier 3 total	**455,810**	**13,575**	**36,265**	**1,535**	**116,775**	**5,430**	**20,535**
Total potential supply across subjects and degree levels		**544,100**	**54,670**	**47,200**	**6,825**	**151,275**	**23,425**	**84,925**

Source: HESA, student record 2015/16 and Destination of Leavers from Higher Education Survey 2015/16
All data has been weighted by full-person equivalent (FPE) and counts rounded to the nearest 5 in accordance with HESA policy. Counts may therefore not sum to totals provided.

EU and non-EU students are estimated to account for 23.4% of graduates who were working in Level 4+ engineering occupations within the UK six months after graduating, and 35.6% of those who have the potential to do so.

A comparison between the two supply calculations, shown in Figure 10.19, suggests that plainly more can be done to attract graduates who may possess the requisite skills into engineering occupations. While it is estimated that 58,671 graduates entered Level 4+ engineering occupations within the UK six months after graduating in the academic year 2015 to 2016, our calculations indicate that 1.4 times that amount (84,923) may have the potential, in terms of skills, to do so. Furthermore, these calculations show the importance of EU and non-EU students to the engineering skills supply pipeline. These students are estimated to account for 23.4% of graduates who were working in Level 4+ engineering occupations within the UK six months after graduating, and 35.6% of those who have the potential to do so.

Figure 10.19 Estimated and potential graduate supply, by domicile – UK

Source: HESA, student record 2015/16 and Destination of Leavers Survey 2015/16

10.6 – The shortfall in engineering skills

Figure 10.20 summarises our supply calculations of people coming out of higher education or apprenticeships able to meet the demand for Level 3+ engineering skills. As discussed in the previous section, we provide two figures for our graduate supply: an 'estimated' number of those who are in engineering roles in the UK six months after graduating, and a 'potential' number that could fulfil these roles.

A notable limitation is that – unlike the supply arising from higher education – no information on employment destinations of apprentices is available. Our calculations therefore assume that 100% of apprentices who complete an engineering-related apprenticeship go on to engineering occupations – an assumption that results in an *underestimate*, rather than an overestimate, of the shortfall.

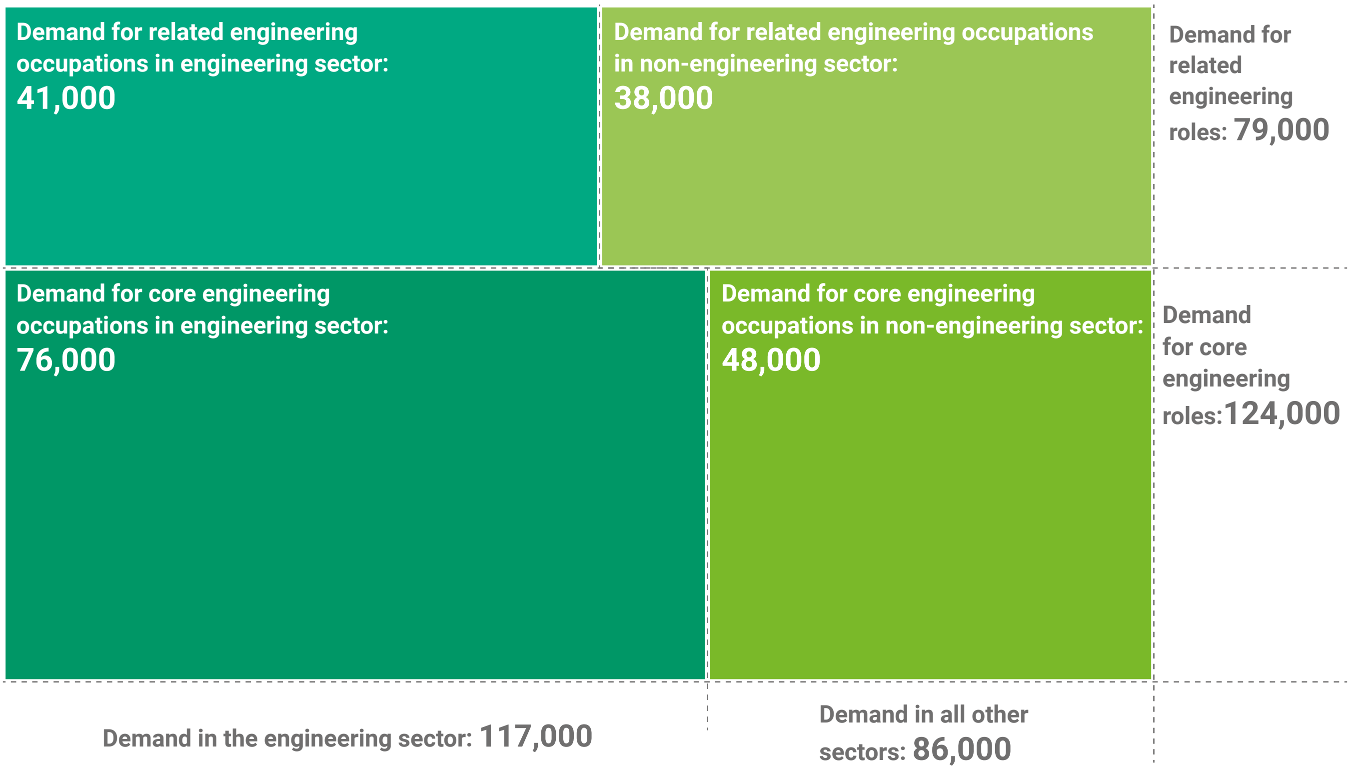
Figure 10.20 Supply numbers arising from higher education and apprenticeship achievements for the academic year 2015 to 2016, by level, subject tier and core/related engineering classification – UK

	Estimated	Potential
Apprenticeship supply		
Level 3 apprenticeships	33,483	
Core engineering	*22,274*	
Related engineering	*11,209*	
Level 4+ apprenticeships	1,171	
Core engineering	*195*	
Related engineering	*976*	
Total apprenticeship supply	**34,654**	
HE graduate supply		
Tier 1 (core engineering)	17,855	36,185
Tier 2 (core engineering)	24,185	28,200
Tier 3 (related engineering)	16,630	20,535
Total HE graduate supply	**58,670**	**84,925**

Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

We consider this supply against the demand to fill engineering occupations at Level 3 and above across the economy – both in terms of 'core' engineering roles (that is, engineering-based roles that require the consistent application of engineering knowledge and skills to execute the role effectively) and more widely (including 'related' roles). Figure 10.21 provides a visual summary of the demand projected to arise within the engineering and non engineering sectors, and for core and related engineering occupations.

Figure 10.21 Summary of projected annual net requirement, by sector and core/related engineering occupation – UK



Based on these calculations, we find there is strong evidence of shortfalls for engineers in 'core' occupations, and engineering skills at Level 3+ more broadly.

Core engineering shortfall

Given the number of graduates who studied either engineering and technology (tier 1) or a STEM subject (tier 2) and the number of Level 3+ apprenticeship achievements in a 'core' engineering framework, we anticipate an annual shortfall of at least 36,936 engineering graduates and technicians to fill core engineering roles. If all those we estimate to be eligible to take up graduate engineering roles did so, the shortfall of graduates would be at least 22,481 (**Figure 10.22**).

Crucially, this is based on the potential supply to core engineering roles. Based on our estimated supply, which provides a more accurate picture of the number in fact progressing onto such roles in the UK, the annual shortfall for Level 3+ core engineering occupations stands at 59,281 – and 44,826 for the annual shortfall at graduate level.

Figure 10.22 Annual shortfall for core engineering occupations, by qualification level – UK

	Estimated	Potential
Level 4+ only (graduate level)		
Core engineering demand (Level 4 only)	87,061	
Supply (Tier 1 & 2 + Level 4 core apprenticeships)	42,235	64,580
Annual estimate shortfall	**44,826**	**22,481**
Total (Level 3+)		
Core engineering demand (Level 3+)	123,790	
Supply (Tier 1 & 2 + Level 3+ core apprenticeships)	64,509	86,854
Annual estimated shortfall	**59,281**	**36,936**

Source: IER, Working Futures 2014-2024 (EngineeringUK extension, 2017)

Overall shortfall – core and related occupations

Our calculations also suggest there is a shortfall when taking into account both further demand for engineering skills in 'related' jobs and the wider supply available among non-STEM graduates likely to possess the requisite level of skills.

Based on our estimated supply, we anticipate there is a net shortfall of 109,608 people with Level 3+ engineering skills required to meet demand for core and related engineering roles across the economy. There is a similarly acute shortfall at graduate level: considering only supply and demand for Level 4 engineering skills, we expect an annual shortfall of 77,077 people (**Figure 10.23**).

Moreover, it is clear from our analysis that even if the current potential supply was funnelled into engineering roles, a shortfall would remain. Subtracting the potential supply of people from annual demand figures yields a shortfall of 83,353 at Level 3+, and 50,822 at graduate level.

Figure 10.23 Annual shortfall for core/related engineering occupations, by qualification level – UK

Level 3		
A	Annual demand	66,014
B	Annual supply	33,483
C	**Net Level 3 shortfall (C=A-B)**	**
Level 4+		
D	Annual demand	136,918
E	Estimated annual supply	58,670
F	Potential annual supply	84,925
G	Engineering-related apprenticeships (Level 4+)	1,171
H	**Net Level 4 shortfall based on estimated supply (H=D-E-G)**	**77,077**
I	**Net Level 4 shortfall based on potential supply (I=D-F-G)**	**50,822**
Level 3+ total		
J	Annual demand (A+D)	202,932
K	Annual estimated supply (B+E+G)	93,324
L	Annual potential supply (B+F+G)	119,579
M	**Net Level 3+ shortfall based on estimated supply (M=J-K)**	**109,608**
N	**Net Level 3+ shortfall based on potential supply (N=J-L)**	**83,353**

Note: Figures relating to the Level 3 supply and demand are presented here to aid interpretation. However, a shortfall figure has not been supplied. This is because taking the supply from Level 3 apprenticeships alone would ignore the possibility that graduates could enter roles that require a lower level qualification than they hold. In other words, it ignores underutilisation of skills.

It is clear from our analysis that even if the current potential supply was funnelled into engineering roles, a significant shortfall would remain.

Leaving the European Union: implications for our estimates

The UK's exit from the European Union represents a significant threat to the supply of engineering skills. A crucial assumption underpinning our potential supply calculations is that graduates of all nationalities who studied in the UK will be eligible to work in the UK. The very high proportion of those studying engineering and technology who are domiciled outside the UK represents a small but particularly vulnerable aspect of engineering's current skills supply chain. Should the eligibility for such migrants to work in the UK or the perception of the attractiveness of working in the UK reduce, then the number would fall from this projected potential supply figure.

Furthermore, *Working Futures*' demand model is based on best available projections for the evolution of the economy and employment, and does not take into account the UK's withdrawal from the EU. This clearly has the scope to impact significantly on the demand side of the equation, through its impact upon engineering activity and enterprises.

The UK's position in relation to the EU places significant uncertainty on both sides of the supply and demand equation. However, whichever of the two versions of the current supply model is used, this analysis confirms that more needs to be done to expand the supply side of the skills equation for the engineering sector in addition to ensuring the continued contribution of graduates from outside the UK to the sector. It is therefore essential that the engineering community work to protect the flow of international talent, expand the UK supply pipeline and communicate the considerable opportunities an engineering career can afford to those already with the requisite skills.

Inflows and outflows in the engineering sector

In summer 2017 EngineeringUK commissioned an independent study from the Institute for Employment Studies (IES) to test the strength of the assumption that movements of workers from other industries into the engineering sector (and vice versa) broadly compensate each other. In addition, the research sought to identify:

- the factors associated with people leaving engineering sectors to work in other sectors
- the size and shape of the potential supply of engineering skills that could be tapped from other sectors (that is, workers in engineering-related occupations currently employed in sectors outside engineering).

Using Labour Force Survey (LFS) data for the period 2006 to 2016, the IES study concluded that annual flows into and out of the engineering workforce over the last decade were indeed broadly net neutral. This has two implications. Firstly, the engineering skills shortfall estimates presented earlier are robust against the omission of net intersectoral mobility. Secondly, while there is potential to reduce the shortfall by attracting more workers from other sectors and improving retention, so far annual net inflows into engineering sectors have been too small to make a tangible difference.

Movements into and out of the engineering workforce

IES's analysis considers different types of labour market movements into and out of the EngineeringUK sectoral and occupational footprint, including:

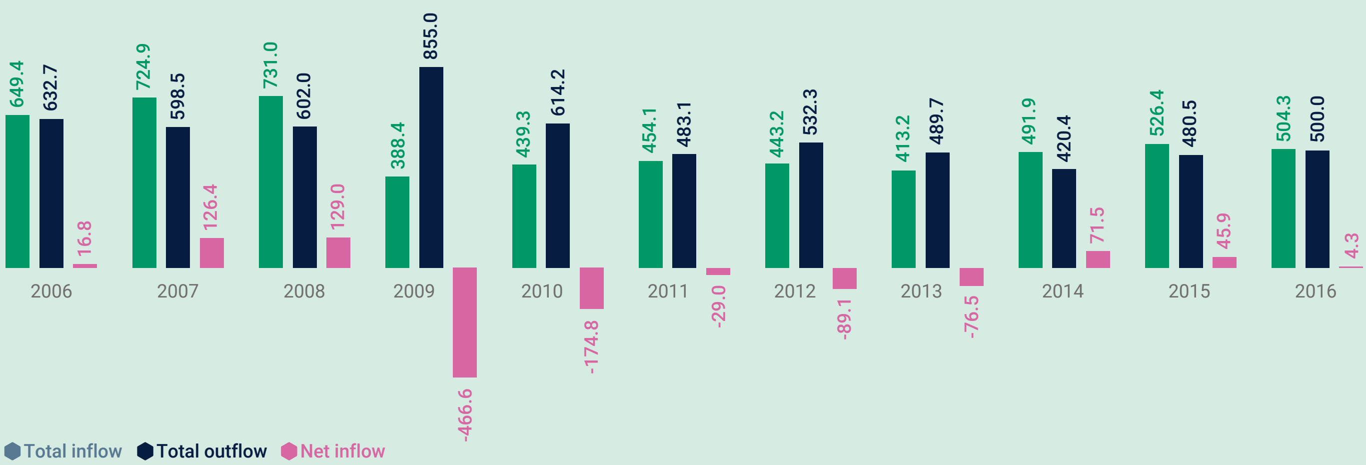
- Workers transferring to/from other sectors/occupations
- Workers entering/exiting the labour market – for example, graduates or unemployed workers starting a job in the engineering sector, or engineering workers going on retirement (or other forms of economic inactivity).

By subtracting the number of leavers from the number of entrants every year, IES estimates an average annual net inflow into the engineering sector/occupations. This gives a good indication of how far hiring workers from non-engineering sectors/occupations goes to mitigate skills shortages in the sectoral and occupational footprints. For example, the requirement for graduates/apprentices would reduce significantly if net flows were large, because it would mean that some of the engineering shortfall is being met by attracting existing workers from other sectors or professions.

IES's analysis of LFS data since 2006 shows that this is not the case. Despite a temporary increase in 'churn' in 2008-09 (due to the onset of the recession and changes in data definitions), annual flows of workers moving into and out of engineering sectors have been stable since then. More importantly, annual differences between inflows and outflows (net inflows) over this period were small and not statistically significant in either the sectoral or the occupational footprints. On average, net inflows totalled:

- 9,000 workers per year in the EngineeringUK sectoral footprint. This represents around 0.2% of the total employment level in the sector.
- 30,000 workers per year - or around 0.7% of the workforce – in the EngineeringUK occupational footprint.
- 3,000 workers per year in in engineering occupations within engineering sectors, corresponding to less than 0.1% of the total employment level.

Inflows and outflows in the EngineeringUK SIC footprint, between 2006 and 2016 – UK (thousands)



Source: Labour Force Survey, April to June quarters 2006-2016

Entrants

In 2016, 504,300 workers entered the engineering sector footprint , including:

- 202,500 entrants from other sectors, representing around 3.5% of the workforce
- 208,000 entrants (or around 5% of the workforce) from unemployment, education or economic inactivity.

More entrants moved into jobs outside of the occupational footprint than into engineer/technician roles, and the majority (79%, or 1.76% of the workforce) did not hold Level 3+ engineering and technology or related qualifications. However, proportions varied across entrants of different origins and destinations. Trends in inflows into the occupational footprint and into engineering-based occupations within the sectoral footprint were similar, with entrants making up 7.5% and 7% (respectively) of the workforce in 2016.

Leavers

The 207,700 workers in the sectoral footprint moving to non-engineering sectors in 2016 accounted for 3.5% of the previous year's workforce. A further 336,800 workers left employment altogether, with those becoming unemployed, or economically inactive each accounting for 2%, and those retiring for 1.4%. As was the case with entrants, the majority of leavers did not hold Level 3 plus qualifications in engineering and technology or related subjects, and were not in engineer/technician roles before they left. Of all the non-engineering sectors from which entrants came, and to which leavers went, the retail trade was largest source and destination sector, although there was a net inflow of around 18,000 workers per year from this sector. Similar patterns were identified within engineering-based occupations in the sectoral footprint and within the occupational footprint, with outflows in 2016 reaching 7.7% and 7% (respectively) of the previous year's workforce.

workers aged 16-24 who had not been engineers or technicians were the most likely to leave

16% of workers in engineering occupations outside of the engineering sector in 2016 worked in the specialised construction activities industry

Factors associated with propensity to leave engineering for other sectors

Using logistic regression, IES also identified a number of factors that make workers more likely to leave engineering for employment in other sectors. These include:

- Former role: workers who had been in an engineering/technician role 12 months previously were less likely to leave than those who had not
- Age: 16-24 year-olds were twice as likely to leave engineering as workers aged 25-39, and 10 times as likely as workers aged 65 or over
- Qualification level: workers qualified below Level 3 and/or in subjects unrelated to engineering and technology were significantly more likely to leave than those holding Level 3+ E&T or related qualifications
- Engineering industry: workers in construction, distribution and transport, and communications and computing showed the highest likelihood of leaving relative to those in mining (the reference industry)
- Region: those working in Northern Ireland and Scotland were least likely to leave, while those working in Yorkshire and the Humber, and the South West were most likely to leave

Notably, other factors – including gender, disability, ethnicity, working hours and employer size – were also tested, but their effect on the workers' propensity to leave was not statistically significant.

A segmentation analysis of workers based on their propensity to leave the engineering sector suggests that former role and age were the key defining characteristics. Young workers (aged 16 to 24) who had not been engineers or technicians were the most likely to leave, with former engineer/technicians aged 40 and over being the least likely.

Potential supply to the engineering sector

As discussed in chapter 7, engineering skills can be found right across the economy, with over 1.7 million individuals working in an engineering role outside of the engineering sector. It is important to understand how these are distributed across sectors, because that will help identify the largest potential source of skilled labour for engineering firms. IES' analysis shows that the specialised construction activities industry has the highest concentration of workers in engineering roles outside of the engineering sector (16%), followed by the wholesale trade (8.3%), public administration (7.9%), retail trade (6.8%) and education (6.5%).

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